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Northeastern Forest Experiment Station

National Association of State Foresters

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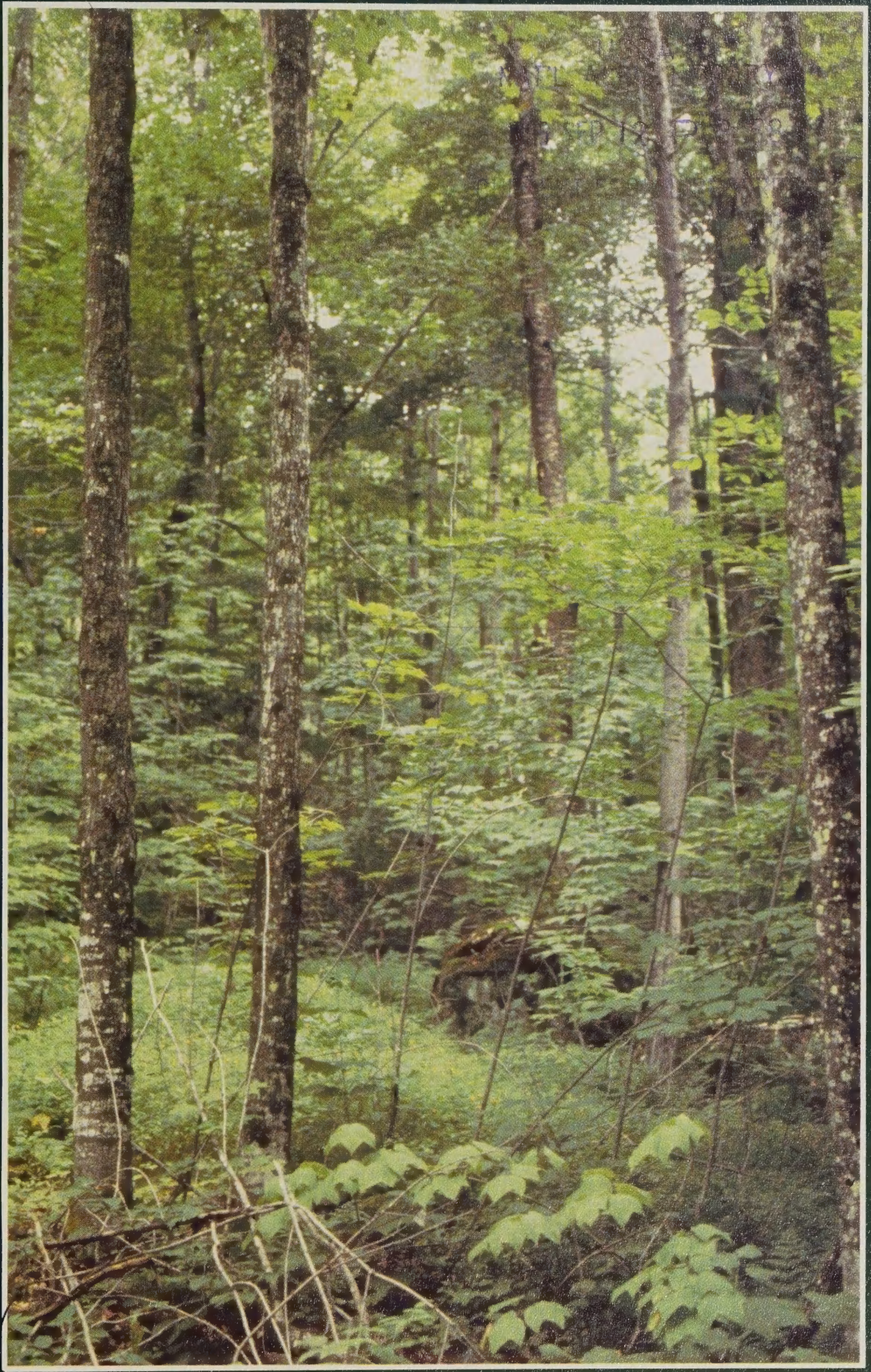

Forest Health Assessment for the Northeastern Area 1993

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Forest Health Assessment for the Northeastern Area 1993

Based on information from the
Federal/State Cooperative Forest Health Protection Program
Forest Inventory & Analysis Surveys
& the Northern Forest Health Monitoring Program

A joint publication of the USDA Forest Service Northeastern Area (NA)
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Forest Health Highlights

This report describes forest health conditions for the twenty states included in the Northeastern Area. It incorporates the most current information available from various State and Federal Forest Health Protection Surveys, Forest Inventory and Analysis, and the Forest Health Monitoring Program. By combining the information from these sources, the report summarizes what is presently known about forest condition and the factors affecting various tree species.

AMERICAN BEECH

An important factor in the health of beech forests is the presence of beech bark disease. First introduced into Maine in the 1930s, the disease has spread throughout the Northeast into Pennsylvania and West Virginia. In 1993, 7 percent of beech trees on Forest Health Monitoring Plots had moderate to severe crown dieback. Growing stock volumes have increased throughout the Northeast, except in Maine where beech bark disease first entered the United States. In many beech stands throughout New England, the percentage of smaller trees less than 15 inches in diameter is high, reflecting the long-term impact of the disease.

ASH

Reports of extensive dieback and mortality of white ash in the Northeast continue, in association with the disease ash yellows and other factors. Results of the Forest Health Monitoring Program crown assessments in 1993 show that of the hardwood species, white ash is second only to beech in percent of trees with severe dieback. Severe dieback of brown ash in Maine is of concern, especially along rivers and streams where the species is typically found growing.

BUTTERNUT

This species may disappear from our forests due to the butternut canker disease. The disease has been found in many areas and is thought to occur throughout the range of butternut, as is evident by extensive tree mortality. A coalition of agencies has been formed to help study the problem and make management recommendations.

EASTERN HEMLOCK

Throughout its range, the volume of eastern hemlock has increased an average of 20 percent during the past 20 years. However, in some stands crown conditions continue to deteriorate. Nearly 8 percent of the eastern hemlock observed on Forest Health Monitoring Plots had moderate to severe dieback. This is in part due to damage from the hemlock woolly adelgid, hemlock scale, and hemlock looper, which are affecting eastern hemlock in various areas.

MAPLES

Red maple and sugar maple growing stock volumes are increasing regionally. Results of studies conducted by the North American Maple Project show that more than 90 percent of the sugar maple have healthy crowns, and the trend has been improving since the project began in 1987. However there are localized areas of concern, as trees are affected by various insect defoliators, such as pear thrips, and past management practices.

OAKS & HICKORIES

Gypsy moth caused defoliation on over 1 million acres in the Northeast in 1993, mostly affecting oaks. Most of the defoliation occurred in Pennsylvania, West Virginia, and Michigan. Hickory growing stock volumes have increased in the past 20 years in most states. There are some local concerns about hickory mortality.

PINES

The southern pine beetle has caused mortality of loblolly and shortleaf pine in Maryland, Delaware, and West Virginia. This insect pest is a natural component of the southern pine forest ecosystem. Jack pine in the Lake states has recently been impacted by the jack pine budworm, a recurring cyclic insect pest. Eastern white pine is growing well in many areas and results from Forest Health Monitoring Plots indicate that crowns are in healthy condition.

SPRUCE & BALSAM FIR

Forest Inventory Data for the years 1973-1990 indicate that balsam fir growth has been generally positive, except for New Hampshire and Maine due to the most recent damage from defoliation by the spruce budworm. Spruce volumes are also increasing regionally. However, there are continued concerns over the condition of the spruce resource in the mountains of New England, New York, and West Virginia. Crown data on Forest Health Monitoring Plots indicate that almost all of the spruce and balsam fir trees had less than 5 percent dieback.

URBAN FORESTS

The overall condition of urban forests is of concern due to many factors such as Dutch elm disease, dogwood anthracnose, oak wilt, and the hemlock woolly adelgid, as well as limited urban tree health care. The Urban and Community Forestry Program is in place to enhance urban forestry technology and encourage woodland management and tree health care.

WEATHER

Thousands of acres of bottomland hardwoods were flooded for 4 to 12 weeks in 1993 in parts of the Midwest. Stressed trees exhibit a range of symptoms including yellow foliage, leaf drop, and dieback. Monitoring is continuing to assess the impact of the floods on urban and rural trees. In the New England states and New York there was extensive browning of red spruce crowns, brought on by severe winter weather.

OZONE

Monitoring of ozone sensitive plants at Forest Health Monitoring Sites in the Northeast showed damage occurring at 10 of 98 sampled sites from Maryland to Maine. Blackberry, milkweed, and ash were the species most often reported with injury.

Introduction

Forests cover a large portion of the northeastern U.S. and provide important renewable resources, recreational opportunities, wildlife habitat, aesthetic benefits, and water quality protection. Questions continue to be raised about the condition and health of these forests, the potential changes resulting from the effects of air pollution and global climate change, and the interaction of these stresses with insect pests and pathogens.

This report describes forest conditions in the twenty states within the Northeastern Area. It is divided into two sections. Section I focuses on forest health conditions based on information obtained through the Cooperative Forest Health Protection Program. Through this joint state-federal effort, forest-wide surveys of forest damage are conducted. From these surveys, information is gathered about the nature and extent of insect, disease, and weather caused damage to trees and forests. Also included in this section is information from Forest Inventory and Analysis Surveys conducted by the USDA Forest Service within each state. These inventory surveys are done approximately on a ten-year basis, and provide periodic updates on forest statistics such as growth rates, volume changes, and rates of mortality and cutting. The inventory periods used in this report for each state vary, but generally range from 1971-1993.

Section II presents results from the Northern Forest Health Monitoring Program implemented in 1990, in cooperation with state forestry agencies, the Forest Service, and the US Environmental Protection Agency. By 1993, in the Northeast a network of permanent plots had been established throughout New England, New Jersey, Delaware, and Maryland. The Lake States began monitoring in 1994 and West Virginia is planned for 1995. The plots are visited annually to monitor tree conditions, such as crown vigor and signs of damage, and to assess ozone bioindicator plant damage on sensitive plants. In addition, beginning in 1994 on some sites, information is also being gathered on lichens, vegetative diversity, and photosynthetic efficiency. The set of forest health

A word about forest inventory terms found in this report

CHANGES IN GROWING STOCK VOLUME. Growing stock is the total volume of live trees with diameters greater than 5 inches. Forest inventories are conducted roughly every 10 years, so a change in volume can be calculated for the period between inventories. The percent change then is the difference in volume between the two time periods divided by the past volume or ((Present - Past)/Past) X 100 = % change in growing stock volume.

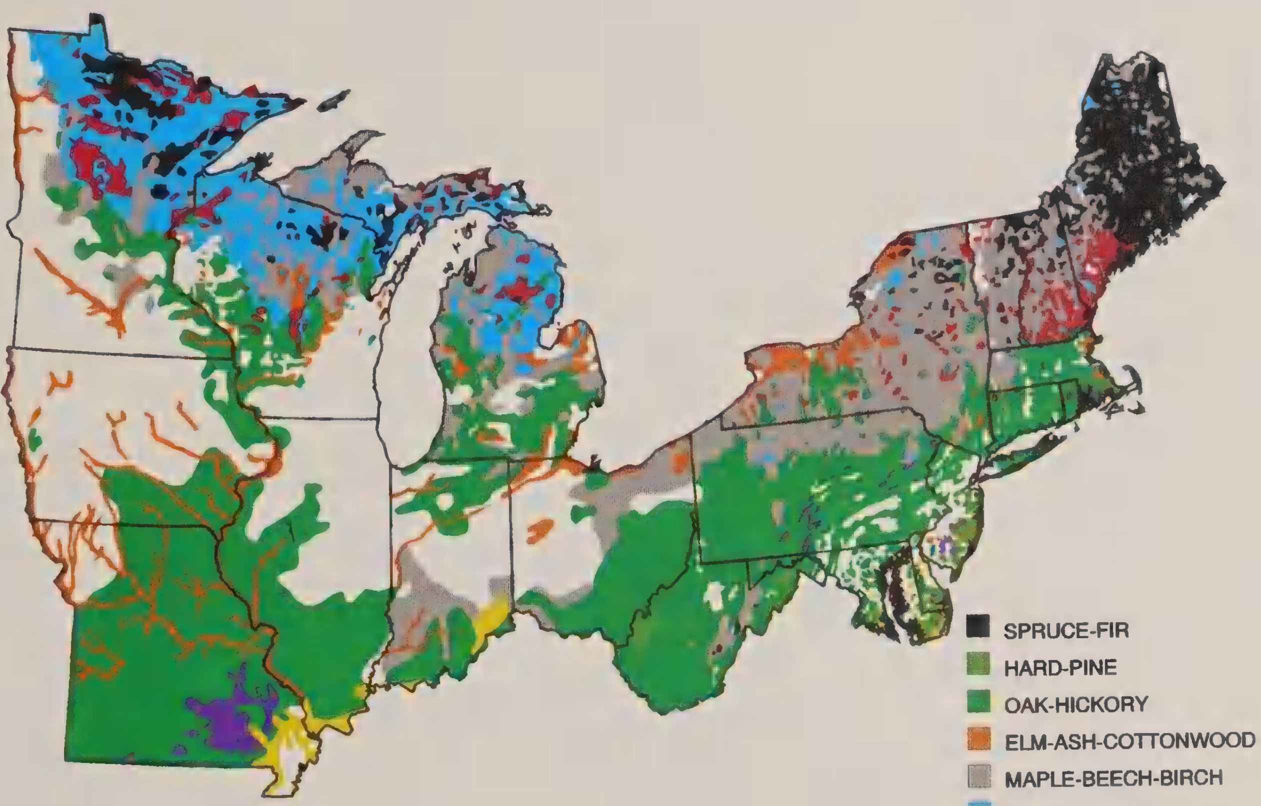
GROWING STOCK VOLUME IN TREES LESS THAN 15 INCHES. One way of assessing the condition of the forest is to look at the percent of the total volume of trees less than 15 inches in diameter. The higher percents indicate more young, small trees.

ANNUAL MORTALITY OF GROWING STOCK. Trees die for a variety of reasons including insects, diseases, weather, fire, competition, and old age. Average annual mortality can be estimated by tallying all trees that died between inventories, calculating their volume, dividing by the number of years between inventories, and expressing this number as a percent of the most present inventory volume. The resulting number represents an estimated annual mortality percentage. The statistic is useful in making regional comparisons. Most regional averages are less than 1 percent per year.

indicators taken together allow assessment of the overall relative health of the ecosystem. Repeated measurements over time allow the evaluation of current status and will provide the baseline with which to evaluate change and trends in forest condition.

Crown vigor is an aspect of tree condition that has become of particular interest in monitoring forest health. The Forest Health Monitoring Program has divided crown vigor into three components: foliage transparency, crown density, and crown dieback. Foliage transparency is a measure of the "fullness" of a tree's crown. The greater the transparency, the more light passes through, indicating that foliage may be missing. Changes in foliage transparency occur as a result of insect feeding, deformed foliage, or reduced amounts of foliage. Crown density, which is the amount of crown branches and foliage that block light coming through the canopy, estimates a tree's crown in relation to a normal or expected shape and size. Each species of tree has a typical crown that varies with site, genetics, damage, or competition. Crown dieback is defined as branchlet or twig mortality in the upper portions of the crown. Crown dieback is often thought to be the first sign of tree stress. Taken together, these three crown rating factors can be used to assess crown vigor.

FORESTS OF THE NORTHEASTERN AREA



List of major introduced insects and diseases in the Northeastern Area

	GENERAL ORIGIN	YEAR OF INTRODUCTION
INSECTS:		
Elm leaf beetle	Europe	1834
Gypsy moth[1]	Europe	1869
Larch sawfly	Eurasia	1880
Larch casebearer	Europe	1886
Beech scale[1]	Eurasia	1890
Pear thrips[1]	Europe	1904
Balsam woolly adelgid	Europe	1908
Smaller European elm bark beetle	Europe	1909
Introduced pine sawfly	Europe	1914
Birch leafminer	Europe	1923
European pine sawfly	Europe	1925
Introduced basswood thrips	Europe	1925
Red pine scale	Europe	1946
Hemlock woolly adelgid[1]	Europe	Prior to 1953
Larger pine shoot beetle[1]	Europe	Prior to 1992
Asian gypsy moth[2]	Europe/Asia	1992
European spruce bark beetle[2]	Europe	1993
DISEASES:		
Beech bark disease[1]	Europe	1890
Chestnut blight[1]	Asia	1904
White pine blister rust[1]	Europe	1906
Larch canker	Europe	1927
Dutch elm disease[1]	Europe	1930
Butternut canker[1,3]	Asia	Prior to 1960
Scleroderris canker	Europe	1962
Dogwood anthracnose[1,3]	Japan	Prior to 1976

[1] Discussed in more detail in this report.

[2] Has not become established yet, although has been found.

[3] Uncertain whether introduced or native.

Section One

Overall Forest Conditions in the Northeastern Area

EXOTIC PESTS

Many current forest health issues in the Northeastern Area are related to exotic or introduced pests. American elm is no longer a major urban shade tree due to the introduction of Dutch elm disease. Chestnut-oak forests are now referred to as oak-hickory forests due to the impact of the introduced chestnut blight on American chestnut. The impacts from exotic pests are partially due to the lack of natural enemies and/or the ability of the host tree species to develop natural defenses.

Some of the introductions occurred very recently, such as Asian gypsy moth and European spruce bark beetle. Both have yet to be established in North America, but could potentially cause major problems if they do. The larger pine shoot beetle was first identified in 1992 in Ohio, which prompted surveys to determine the extent of its distribution in the United States. It has been found in states surrounding the Great Lakes, mostly affecting pine Christmas tree plantations (Figure I-1).

The introductions are not limited to insects and diseases, but include plant species. The potential impact from introduced plant species results from the reduction and/or elimination of native vegetation. A partial list for the Northeastern Area includes: mile-a-minute, purple loosestrife, leafy spurge, kudzu, Japanese honeysuckle, and even Norway maple. The loss of native vegetation can have serious impacts on the animals that rely on these species for survival.

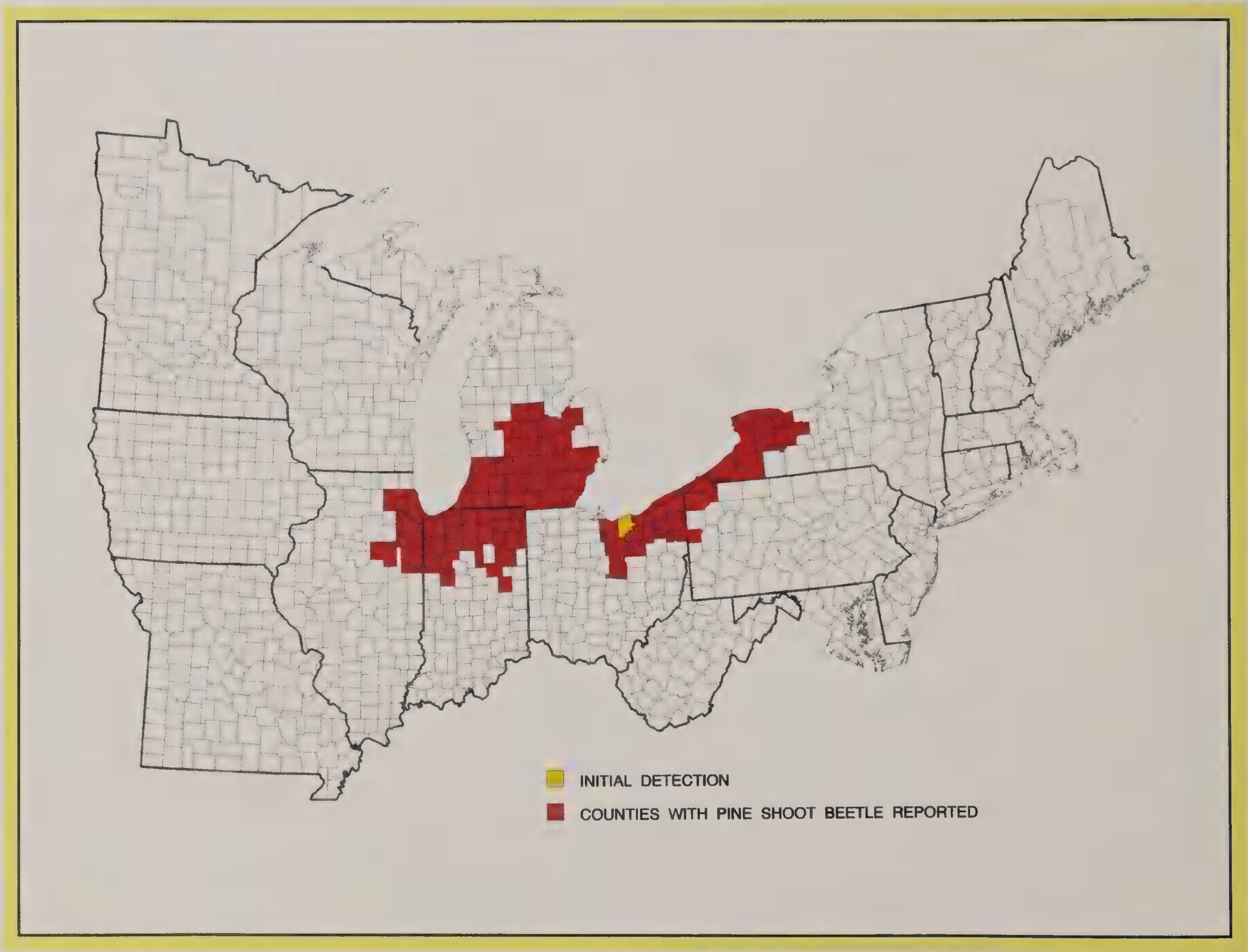


FIGURE I-1. *Distribution of the larger pine shoot beetle in 1993.*

Cankers on American beech caused by beech bark disease.

IN 1993, nearly 4 percent of beech trees on Forest Health Monitoring Plots had crown density rated as poor, and 6 percent had crown dieback rated as moderate to severe.

AMERICAN BEECH

American Beech is a common deciduous tree that can be found from Maine to Florida, and west to Wisconsin and Texas. It is a species that is very tolerant of shade and is often found growing in association with maples and birch. The forest type known as maple/beech/birch encompasses nearly 5 million acres in the Northeast. The largest concentrations of American beech are found in New York, Pennsylvania, and West Virginia. In New England, the Mid-Atlantic states, and the Northcentral states, the volume of American beech has generally increased with the exception of Maine, Delaware, and Illinois, where a 6, 47, and 17 percent decrease in growing stock volumes has occurred, respectively (Table I-1). New York, Vermont, and Wisconsin have higher than average annual American beech mortality rates, as a percent of growing stock volume.

A very important factor in the health of American beech is beech bark disease (Figure I-2). This disease, first introduced into Maine in the 1930's from Canada, has spread throughout New England into Pennsylvania and West Virginia. By the mid-1970's, it was estimated that over 30 percent of the American beech in New Hampshire and Vermont and 50 percent of the American beech in

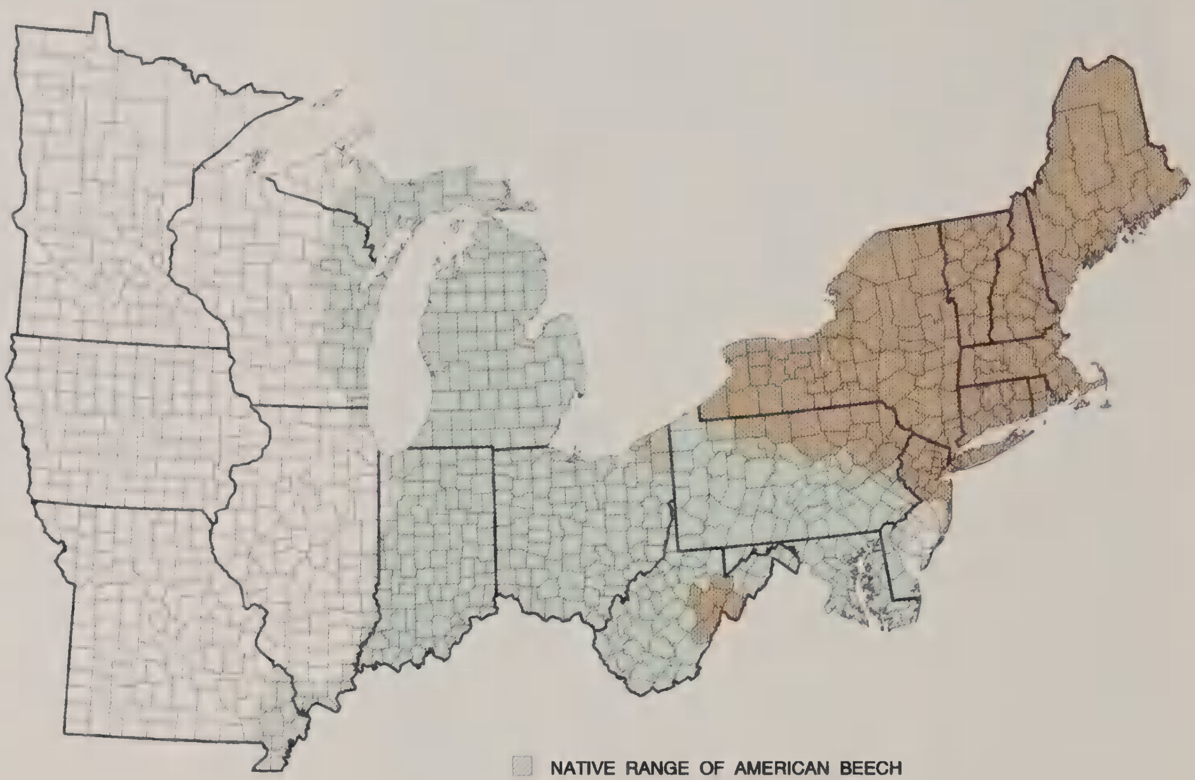


FIGURE I-2. *Distribution of beech bark disease in 1993 and the native range of American beech.*

Maine over 8 inches in diameter were killed by this disease. It is worth noting that in New England, the percent of growing stock volumes in trees less than 15 inches in diameter is quite high. In Maine, where American beech volume is decreasing, 87 percent of the growing stock volume is in smaller trees. Mortality has also occurred on over 500,000 acres of forest containing American beech in West Virginia and on over 250,000 acres in New York. In New England, larger American beech are being killed by the disease and then replaced by young, smaller beech. In many instances, these young trees are sprouts and are just as susceptible to the disease. Most become infected by beech bark disease, but because they are able to outgrow infection, they are not always killed. However, this so-called "aftermath" forest consists of many highly deformed, defective trees.

Periodically, various defoliators also impact beech. In 1993, American beech in Pennsylvania was affected by elm spanworm which caused nearly 125,000 acres of defoliation in forested areas.

Table I-1. *Percent change in growing stock volume and annual mortality rates for American beech.*

STATE	PERCENT CHANGE IN GROWING STOCK VOLUME BETWEEN INVENTORY PERIODS	PERCENT OF GROWING STOCK IN TREES LESS THAN 15 INCHES IN DIAMETER	ANNUAL MORTALITY AS A PERCENT OF GROWING STOCK VOLUME
New York & New England			
CT	26	62	0
ME	-6	87	1
MA	20	78	.5
NH	64	73	.2
NY	40	75	1.5
RI[1]	*	*	*
VT	28	72	1.1
Average	25	77	1
Mid-Atlantic			
DE	-47	47	*[1]
MD	30	49	0
NJ	85	56	.1
OH	64	40	.5
PA	24	63	.4
WV	19	52	.2
Average	27	55	.3
Northcentral			
IL	-17	17	.4
IN	30	38	.3
MI	35	53	.2
MO	54	32	.6
WI	13	51	1.9
Average	31	49	.3

[1] Insufficient data.

ASH

White ash and black ash are components of the elm-ash-cottonwood forest type which encompasses over 10 million acres in the northeastern and north-central states from Maine to Minnesota. White ash is the most common native ash species, while black ash is found more often along streams and rivers. Also white ash is more commercially important, however black ash is valued as a resource for basket making and other products.

In the central Appalachians, ash growing stock increased 36 percent since the last inventories. Average annual mortality is 0.4 percent of growing stock volume for all ash species and all size classes. However, ash in some areas is affected by various factors, especially ash yellows. By 1993, this disease, caused by a mycoplasma-like organism, was confirmed from almost every state within the Northeastern Area, except Maine, New Hampshire, Rhode Island, New Jersey, Maryland, and Delaware affecting white ash.

Not all of the observed white ash problems can be attributed to the disease, since damage from drought, insects, and rust diseases are also found in association with declining trees. In 1993, there were reports of extensive dieback in ash crowns in New England and New York. This followed a previous year of heavy seed crop in the affected areas. Symptoms included late leafout, tufting of foliage, and in some instances dead buds and branch tips. In New York, ash anthracnose, a foliage disease was reported in 1993 on 105,000 acres.

Ash crown condition on New England Forest Health Monitoring Plots 1993

	PERCENT OF TREES	
CROWN DIEBACK	none-light	moderate-severe
Average, all hardwoods	95.7	4.3
American beech	93.0	7.0
White ash	93.2	6.8
CROWN DENSITY	good-average	poor
Average, all hardwoods	98.0	2.0
American beech	96.1	3.9
White ash	96.9	3.1

Results of Forest Health Monitoring assessments of white ash crown conditions in 1993 show that white ash is second only to American beech in percent of trees with severe dieback and poor crown density.

Decline of black ash was reported in 1993 in Maine on 120,000 acres. Numerous trees with severe crown dieback have been observed along streams in Maine. A cooperative effort to study the extent and causes of the decline has been initiated by the Forest Service in cooperation with the Maine Forest Service, University of Maine, and Native American tribes in the state.

BUTTERNUT

Butternut, or white walnut, is associated with many other hardwood species and occurs sporadically throughout the Northeast. The tree is most valued for its nut production for wildlife and for furniture wood. In the past the majority of butternut timber production has been in West Virginia, Wisconsin, and Indiana. It is hard to find healthy butternut in forest stands today, as the species is being threatened by a

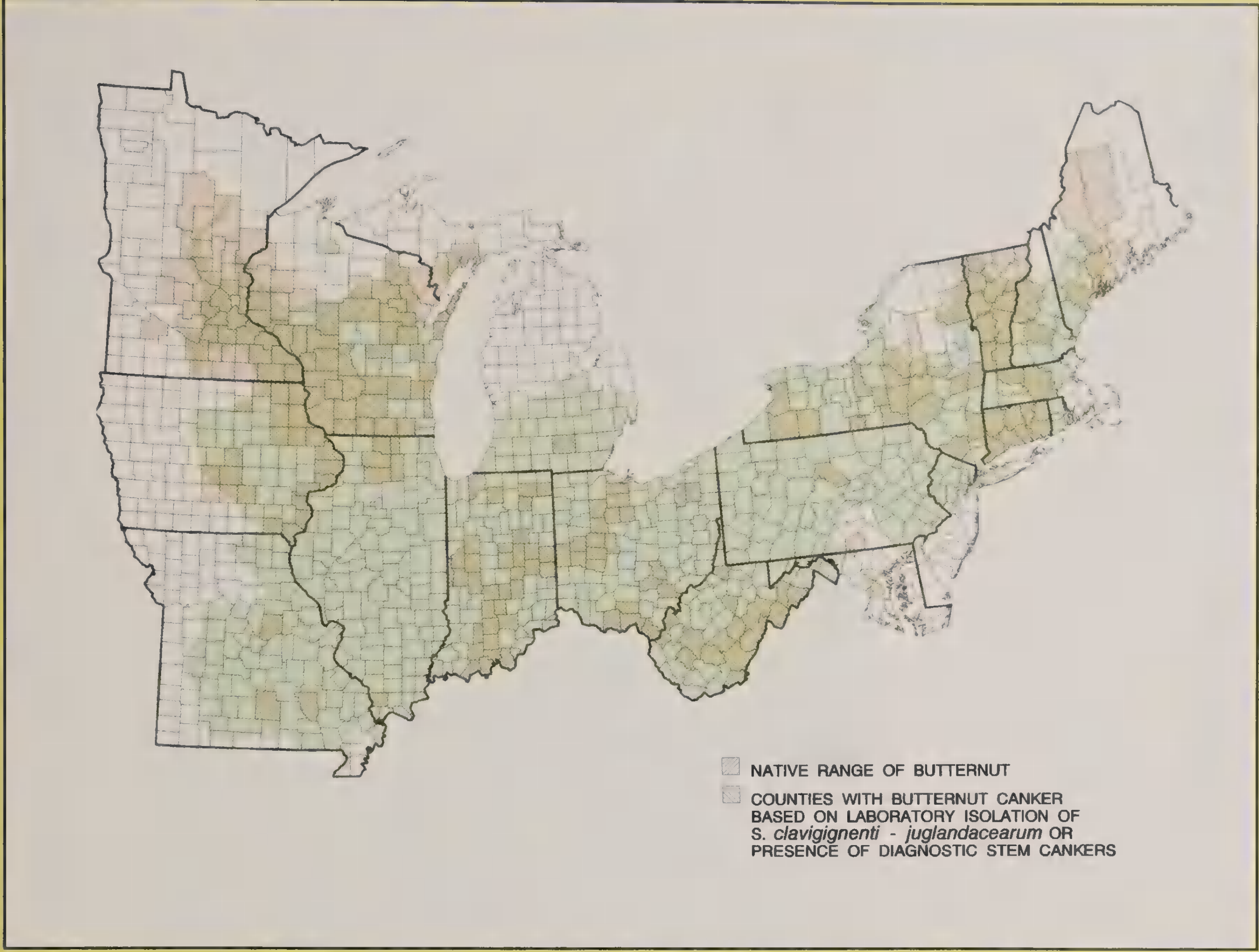


FIGURE I-3. *Distribution of butternut canker in 1993, based on recent surveys, and the native range of butternut. (It is thought that the disease occurs throughout the range of butternut.)*

devastating disease known as butternut canker.

The disease was first reported occurring in Wisconsin in the mid-1960s, but was probably in the United States prior to that time. It is now present throughout the range of butternut (Figure I-3). The cankers girdle the branches and tree stems, causing mortality. There is no known control for butternut canker disease. Efforts now center on finding resistant individual trees within infected stands.

In 1993, a ground survey confirmed the presence of the disease in central coastal Maine. Surveys for the disease were also conducted in New York, where most of the counties surveyed were found infected, and Vermont, where the presence of the disease was confirmed throughout the state. In Wisconsin, where over 1000 trees were sampled in 32 counties, 91 percent of the live trees were found to be infected and 27 percent of the surveyed trees were dead. In the last decade the number of live butternut decreased 58 percent in Wisconsin and 84 percent in Michigan. Several evaluation surveys indicate that the disease has spread rapidly within infected stands.

BUTTERNUT COALITION FORMED

During the past year, a number of interested conservation groups, and state and federal agencies, have formed an association dedicated to the protection of butternut. This work has proceeded under the leadership of the Forest Service, North Central Forest Experiment Station, and has resulted in the development of butternut retention guides, screening of resistant trees, and the establishment of seed orchards with trees that have the potential resistance to butternut canker.

EASTERN HEMLOCK

Eastern hemlock ranges from northern New England, west to Minnesota and south through the Appalachian Mountains. It occurs in pure forests or associated with other trees such as eastern white pine, balsam fir, spruce, or maples. Eastern hemlock is also widely planted in the Northeast as an ornamental. Throughout its range in the Northeast, the volume of eastern hemlock has increased by an average 23 percent during the past 20 years (Figure I-4). Some of the largest gains occurred in Massachusetts, Connecticut, Pennsylvania, and New York. Loss of eastern hemlock in Wisconsin is attributed to a lack of new eastern hemlock seedlings due to feeding by deer, and the timber industry has not been actively managing for eastern hemlock. Forests in Wisconsin are being inventoried in 1994, and those data should reveal whether the previous trend has been reversed. In Michigan, for example, the trend in the previous two inventories indicated a loss of eastern hemlock, but this trend was reversed during the past 10 years. Despite these gains in eastern hemlock volumes, several insects are causing concern in localized areas. The hemlock looper (both fall and spring flying) defoliated large areas of eastern hemlock in northern Maine and in parts of Vermont, New Hampshire, Massachusetts, and Connecticut during 1991 to 1993. Though defoliation was less widespread in 1993, with only Maine reporting areas of aerially detectable defoliation, the impact of several years of defoliation upon the eastern hemlock is potentially damaging to trees in some areas.

HOW, THE HEMLOCK WOOLLY ADELGID DAMAGES TREES

The adelgid, which is sometimes referred to as an aphid, feeds by sucking the sap from young twigs. Over time, this causes needles on the twig to discolor from green to yellow, and eventually causes the needles to fall off. This loss of needles impairs tree health and may cause tree death.

Hemlock woolly aldegid infestation on eastern hemlock.

The hemlock woolly adelgid, an introduced pest, continues to affect eastern hemlock particularly in parts of Connecticut, New Jersey, Pennsylvania, and West Virginia (Figure I-5). In New Jersey, the adelgid infestation has reached epidemic proportions with 18,000 acres out of a total hemlock resource of 26,000 acres now infested. Some areas in New Jersey have such severe adelgid infestations that tree mortality is occurring.

Eastern hemlock crown conditions, as assessed on Forest Health Monitoring Plots in New England, show relatively high amounts of trees with severe dieback and poor crown density. Nearly 6 percent of hemlocks were observed in 1993 to have severe crown dieback—this is 4 times greater than the percentage for all conifers monitored. Five percent of all hemlocks observed had poor crown density, which is nearly 3 times greater than the average for all conifers. Hemlock crown conditions and the impact of hemlock woolly adelgid is being closely monitored.

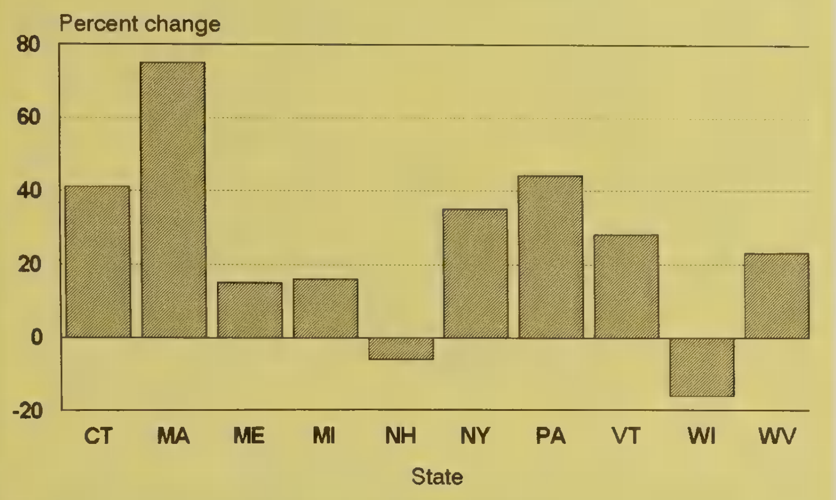


FIGURE I-4.
Percent change in eastern hemlock growing stock volume. (Individual state inventory periods vary, but range between 1969 and 1993.)

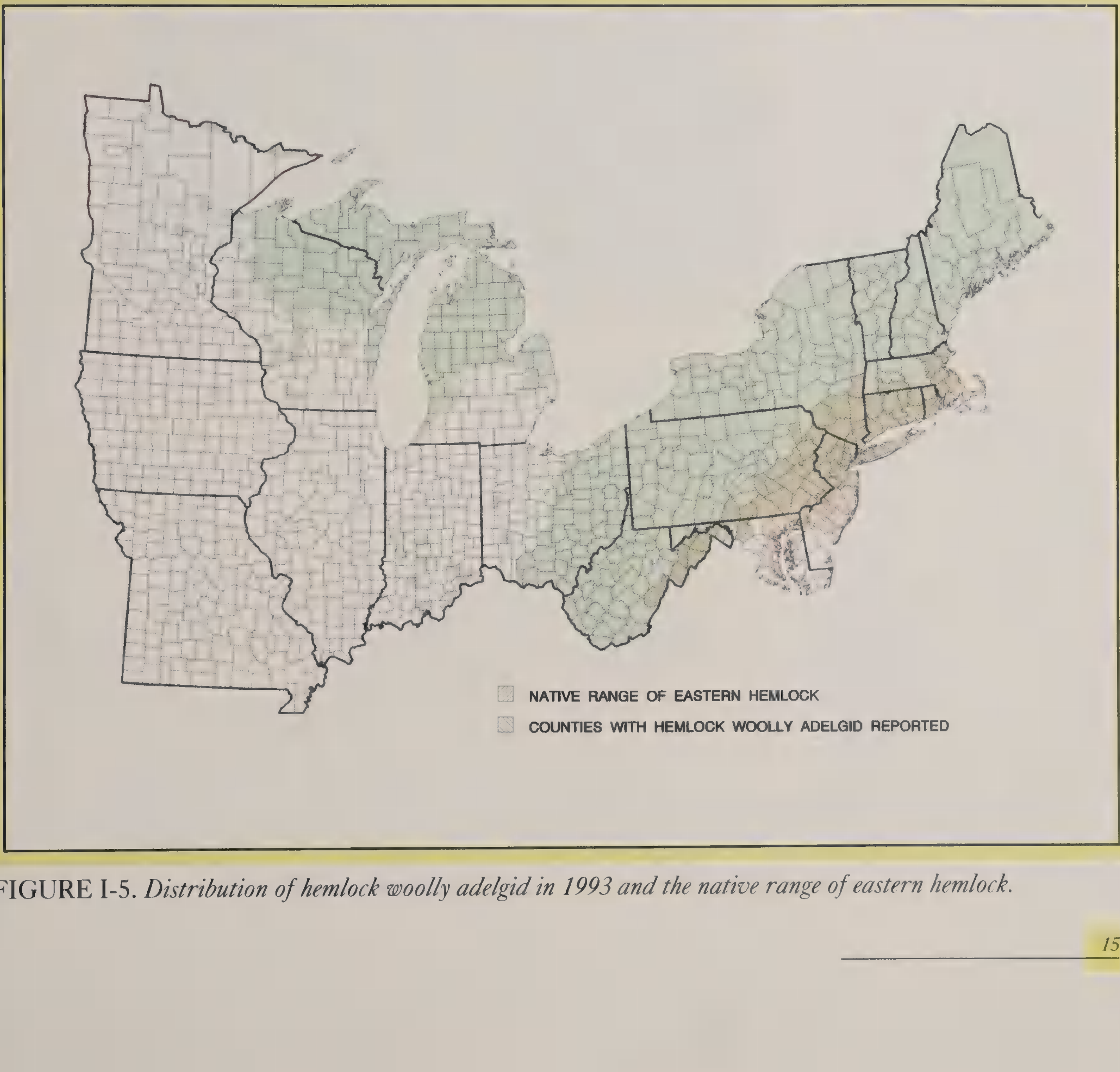


FIGURE I-5. *Distribution of hemlock woolly adelgid in 1993 and the native range of eastern hemlock.*

MAPLES

Of the hardwood species growing in the East, maples are second in abundance to the oaks and are one of the fastest growing components of our hardwood forest. Sugar (hard) maple and red (soft) maple together account for 17 percent of all hardwood volumes in the East. Figure I-6 illustrates changes in growing stock volumes for both sugar and red maples. The largest gains in sugar maple volumes occurred in Massachusetts, Indiana, and the Lake states. In Ohio, there was a 138 percent increase in red maple volume.

The increases may be due to several factors. Both sugar and red maple are very tolerant of shade and both are prolific seeders. Red maples will increasingly occupy sites as openings are created or other species are cut and removed. Sugar maple tends to increase in forests where cutting or disturbance is absent or limited to small patches, permitting this very shade tolerant species to thrive. Large increases in one species mean others lose ground. For example, in Ohio, red maple has replaced hickory as the most abundant tree species in the forest.

In recent years, there has been concern expressed over the health of sugar maple. Sugar maples, used for the production of maple syrup and as a roadside and yard tree, are a valuable commercial and aesthetic component of our forests in the Northeast. In many cases, various stressing agents have been associated with dieback and decline of individual sugar maples, especially insect defoliators and physical damage. In northern New York, the forest tent caterpillar defoliated over

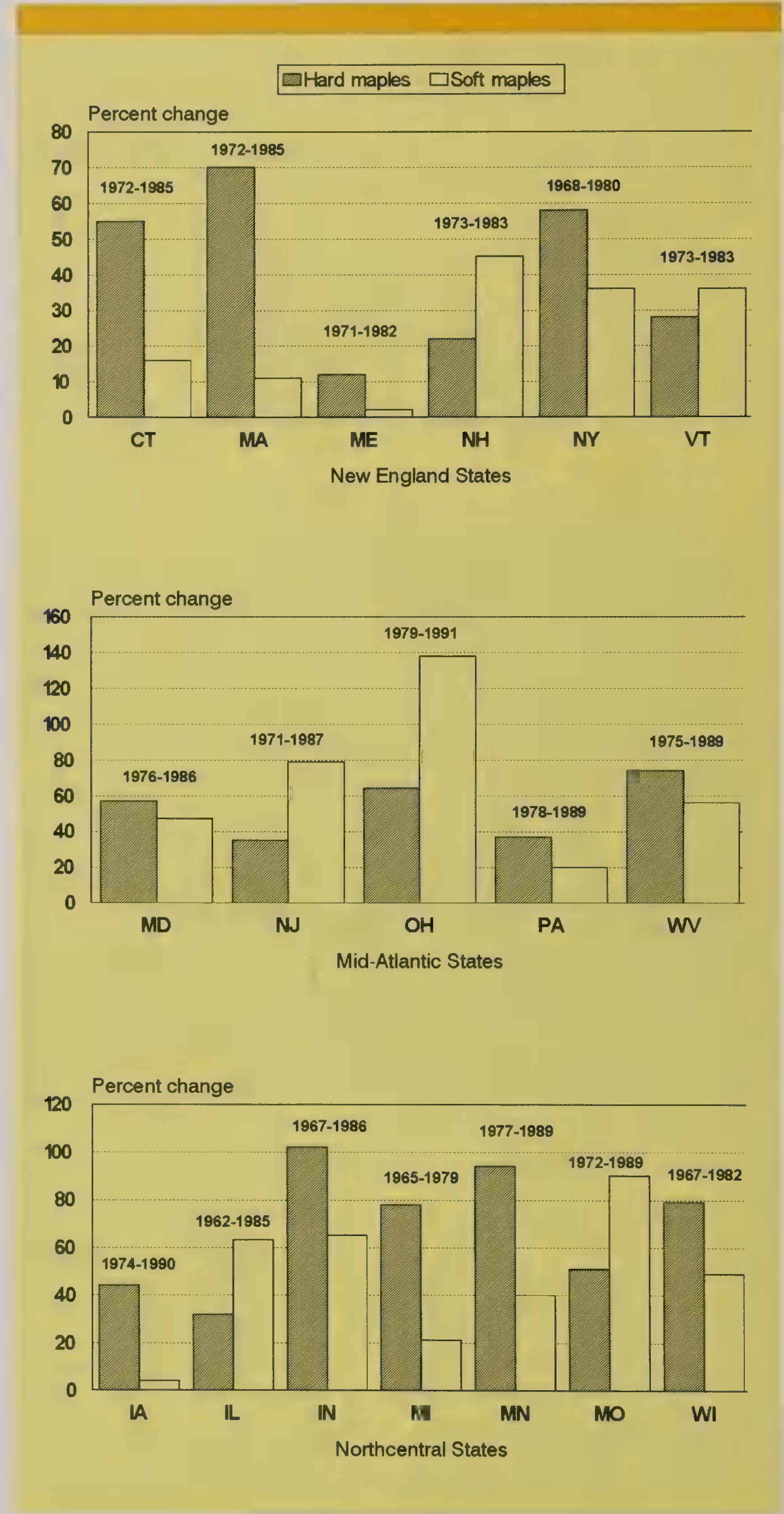
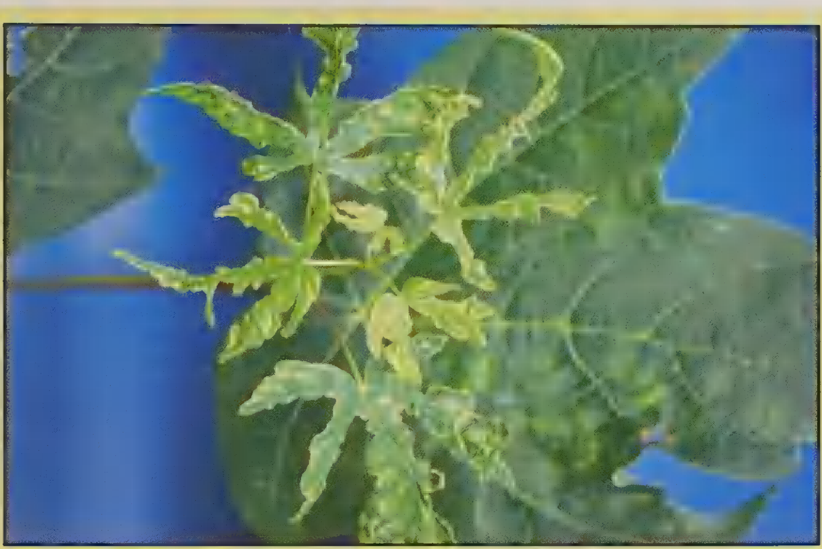


FIGURE I-6. *Percent change in growing stock volume for hard maples (includes sugar and black) and soft maples (includes red and silver) in the New England, Mid-Atlantic, and Northcentral states.*

Pear thrips defoliation of sugar maples 1993

	ACRES DEFOLIATED	PERCENT OF MAPLE/BEECH/BIRCH FOREST
New York	**617,260**	**6.6**
Ohio	**200**	**<0.1**
Vermont	**83,939**	**3.1**
Pennsylvania	**76,905**	**1.3**



Sugar maple foliage damaged by pear thrips.

120,000 acres of sugar maple in 1993. Pear thrips defoliation continues in Vermont, Pennsylvania, and New York; however, the area affected is down from the 1980s when the most extensive damage occurred.

In northern Pennsylvania, an area of 260,000 acres has been defoliated over the past several years by the elm spanworm. Most heavily impacted within this area has been red maple and American beech. Spraying with the bacterial insecticide, *Bacillus thuringiensis*, was planned in 1994 to prevent tree mortality.

The North American Maple project has been collecting information since 1988 at permanent sample sites throughout eastern Canada and the northeastern U.S. Results of this survey have shown that more than 90 percent of all sugar maples sampled were considered to have healthy crowns. The proportion of upper canopy sugar maples rated with more than 15 percent dieback was about 6 percent in 1993 in sugar-bushes and about 4 percent in undisturbed sites. This was a decrease from 10 percent in sugar-bushes and 7 percent in undisturbed sites in 1988. Foliage transparency also improved during this time period. Most of the crown condition improvements are due to decreased damage from insect defoliation and recovery from severe drought in the late 1980s Of those few trees with more than 50 percent dieback, nearly all had major root or trunk damage. Within the survey plots, sugar maple mortality is estimated to be only 1 percent of trees per year. Forest Health Monitoring Data indicate that almost all of the red maple and sugar maple sampled had average or good crown densities.

This isn't to say that local problems do not occur. In Pennsylvania, for example, red and sugar maple volumes increased statewide. However, several northwestern counties in an area known as the Allegheny Plateau are experiencing decreases in sugar maple growing stocking relative to other species. Some of this may be due to the affects of pear thrips or elm spanworm defoliation or deer feeding. Forest health specialists have been gathering information related to this problem.

OAK-HICKORY FORESTS

OAK

Our present oak-hickory forests are the result of the chestnut blight, in conjunction with past management practices. Forests once referred to as chestnut-oak covered huge areas of the eastern U.S. from southern New England to northern Georgia. Chestnut blight, caused by a fungus, was introduced to this country in 1904, and by the 1930s, most chestnut trees were infected and dying. Natural replacement of the American chestnut followed, resulting in forests in which oaks, yellow poplar, and hickory became dominant. Today, we refer to these replacement forests as oak-hickory forests, but as the noted ecologist

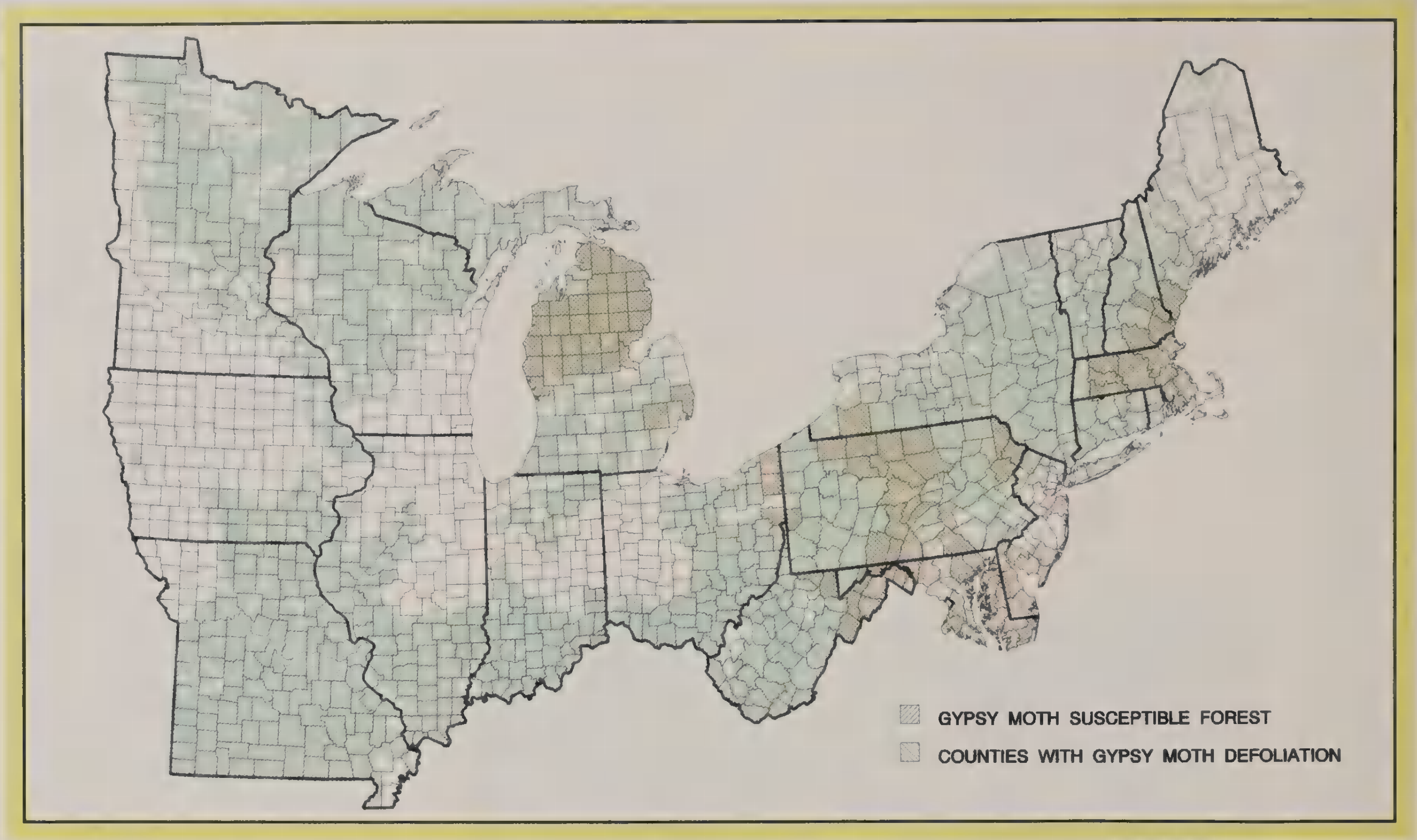


FIGURE I-7A. *Gypsy moth defoliation in 1993 and the distribution of susceptible forests.*

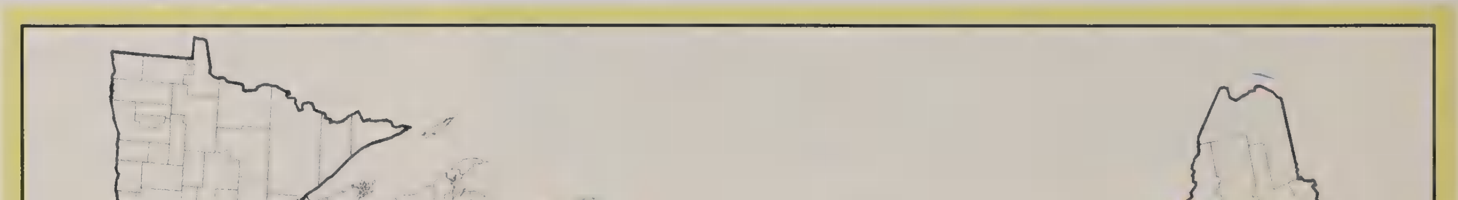


FIGURE I-7B. *Gypsy moth defoliation in 1992 and 1993.*

CONTROLLING THE GYPSY MOTH, NATURALLY

During the past several years, a fungus known as *Entomophaga maimaiga* caused increasing amounts of mortality to gypsy moth larvae. The fungus, possibly originating in Japan, spreads during cool, wet spring conditions. Significant caterpillar mortality has occurred in New Jersey, Maryland, New York, and New England. The presence of this fungus within gypsy moth populations may help to limit the explosive nature of gypsy moth outbreaks, and may reduce the need for insecticides.

Lucy Braun wrote in 1950, "it is impossible as yet to predict the final outcome of the partial secondary successions everywhere in progress."

Within the present day oak-hickory forests, the forest health concern is the gypsy moth. This defoliating insect was introduced into the U.S. in 1869 in Massachusetts. It has gradually spread throughout the East, now affecting forests from Maine to Virginia and west to Wisconsin (Figure I-7). The gypsy moths feed on a variety of hardwood species, but favor oaks, sweetgum, American basswood, and willow. Repeated defoliation can result in growth loss, tree mortality, changes in forest composition, and loss of habitat for various animal species. In some areas, oak mortality due to gypsy moth defoliation has been significant. Areas of Pennsylvania experienced extensive oak mortality during outbreaks in the late 1980s. Gypsy moth will not disappear from these forests, and a new balance must be struck between forest and insect. Overall, in Pennsylvania, a state with a 20-year history of gypsy moth defoliation, oaks still account for 43 percent of the total forest volume. However, there is concern for the lack of regeneration in some areas. Pest specialists have conducted numerous aerial spray programs to protect both urban and nearby forested areas (Table I-2).

TABLE I-2. *Gypsy moth defoliation and acres treated with various insecticides in the Northeastern Area in 1993 (all ownerships[1]).*

STATE	ACRES DEFOLIATED	BACILLUS THURINGIENSIS[2]	DIMILIN[2]	GYPCHEK[2]	TOTAL[2]
DE	26687	14817	4255	0	19072
ME	50694	0	0	0	0
MD	69448	26004	15970	463	42437
MA	88684	0	0	0	0
MI	399306	230404	0	0	230404
NH	10075	0	0	0	0
NJ	27710	12309	0	0	12309
NY	2000	0	0	0	0
OH	610	1700	2738	0	4438
PA	334404	46345	78857	0	125202
WV	202490	10521	58535	2961	72017
TOTAL	1212108	342100	160355	3424	505879

1. Includes suppression projects conducted by states, national forests, and other federal agencies.
2. Bacillus thuringiensis, a biological insecticide; Dimlin, a synthetic growth regulator; and Gypchek, a propagated naturally occurring virus.

HICKORIES

Of the total amount of hardwood volume in the East, oaks comprise nearly a third while hickories account for only about 4 percent. The hickory bark beetle is the most important insect pest of hickory, affecting all species. During drought years, outbreaks of this insect can develop, killing large numbers of trees.

Recently some concern has been raised over declining hickory in various parts of its range. Table I-3 shows that hickory volume has increased in most states during the past 20 years, though some areas have a seemingly high proportion of volume in smaller diameter trees. Rates of mortality appear to be well within acceptable limits over most parts of the range of hickory. In general, hickory mortality rates appear to be higher in the northeast than in the north-central states.

Table I-3. *Percent change in growing stock volume and annual mortality rates for hickory.*

STATE	PERCENT CHANGE IN GROWING STOCK VOLUME BETWEEN INVENTORY PERIODS	PERCENT OF GROWING STOCK IN TREES LESS THAN 15 INCHES IN DIAMETER	ANNUAL MORTALITY AS A PERCENT OF GROWING STOCK VOLUME
CT	19	85	.5
DE	-70	71	NA
IL	52	70	1.0
IN	19	67	.5
IA	74	82	.4
MD	12	67	.6
MA	-22	92	2.1
MI	3	79	.1
MN	54	87	.3
MO	45	85	.8
NJ	62	78	.2
NY	23	82	.4
OH	35	68	.6
PA	12	78	.8
RI	73	95	.7
WV	32	77	.4
WI	82	90	.2
Average	31	76	.6

PINES

Various species of pine are found within the Northeastern Area. Red pine and jack pine occur in the northernmost parts of the area including Minnesota, Wisconsin, and Michigan. Pitch pine, a tree of great diversity in form and habitat, is found from North Carolina to West Virginia and north through parts of Ohio and Pennsylvania into New England. These three species are known as the northeastern yellow pines. One species of pine often found in association with red and jack pine is the eastern white pine. Eastern white pines can be found growing in pure stands or with other species such as, eastern hemlock, red maple, and oaks. A group of pines known as the southern yellow pines are also found in parts of the Northeastern Area. These are loblolly, shortleaf, and Virginia pines. The largest amounts of southern yellow pines along with pitch pine in the Northeast are found in the states of Delaware, Maryland, New Jersey, Pennsylvania, West Virginia, Missouri, and Ohio. However, volumes of red and jack pine in the Northeast are nearly 5 times that of the southern yellow pines.

Recently, the southern pines growing in Maryland, Delaware, and West Virginia have experienced increasing amounts of tree mortality caused by the southern pine beetle (Figure I-8). This insect, which has caused significant mortality in pines throughout the Southern states for many years, periodically erupts to outbreak proportions in the Northeast. In 1993, 1,400 acres of beetle-caused mortality were reported in Delaware, 2,000 acres in Maryland, and 500 acres in West Virginia. The southern pine beetle is a natural part of the southern pine ecosystem. The insect is not expected to disappear and control efforts revolve primarily around salvage logging of dead trees. Sometimes recently infested trees and nearby healthy trees are removed from forested areas to stop addi-

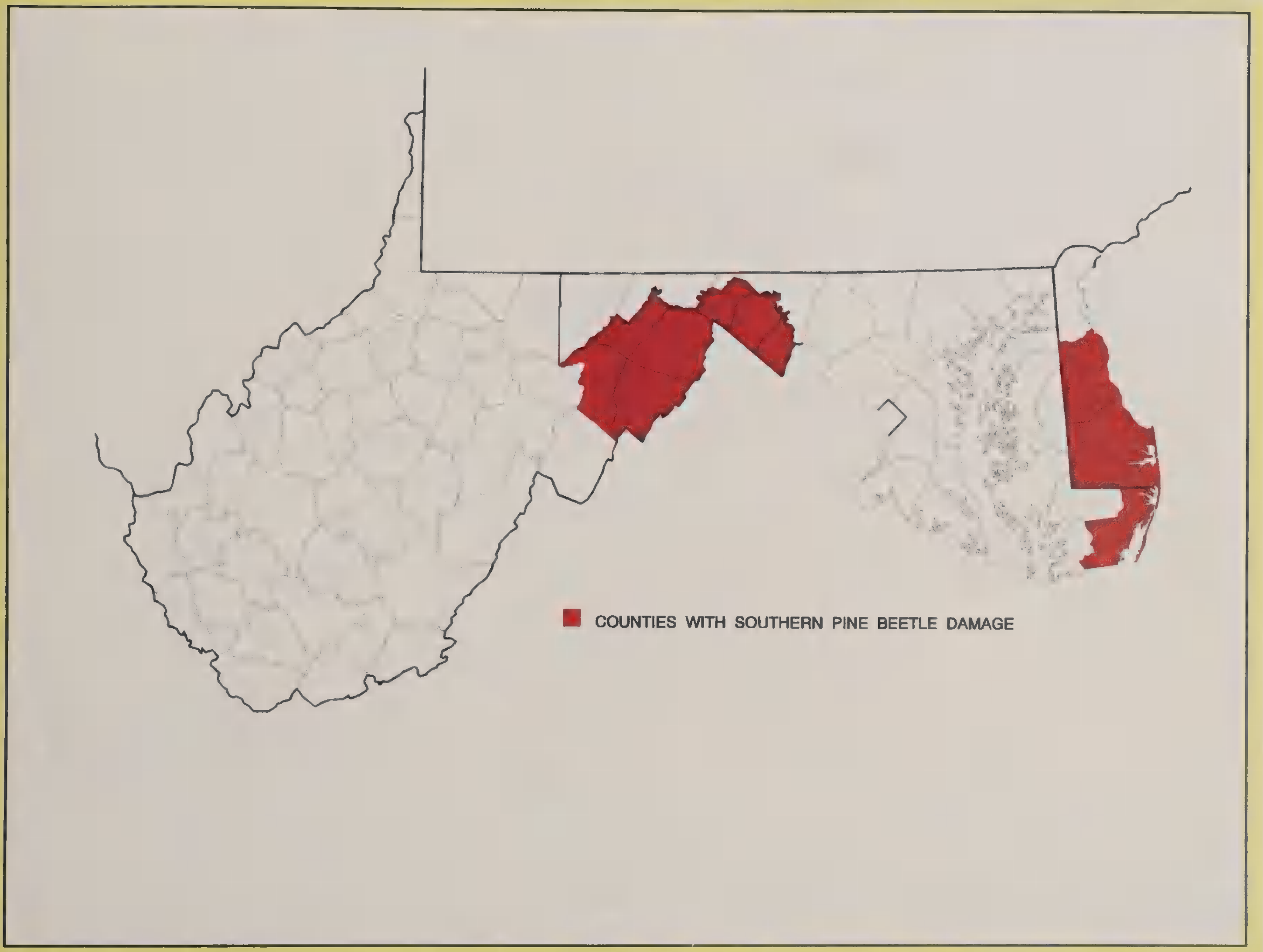


FIGURE I-8. *Distribution of southern pine beetle in 1993.*

tional tree mortality.

Jack pine in Michigan, Minnesota, and Wisconsin have been subjected to defoliation by the jack pine budworm in recent years. Like the southern pine beetle, outbreaks of the jack pine budworm occur in cycles. Moderate to heavy defoliation occurs for 2 to 3 years, followed by 6-10 years of no detectable feeding damage. During the 1970s and 1980s, jack pines in the Lake states sustained heavy losses especially in older forested areas. In 1993, jack pine budworm caused defoliation on over 400,000 acres in northern and central Wisconsin, and in parts of Michigan and Minnesota (Figure I-9). Most surveys, however, indicate declining jack pine budworm populations for the near future.

EASTERN WHITE PINE

Eastern white pine extends from Maine to the Lake States and south throughout the Appalachian Mountains. It grows in a variety of conditions from pure stands to stands in which it is only a minor component. In mixed stands it is found associated with many different species including aspen, birch, oaks, and hickories. Part of its adaptability is the result of its moderate shade tolerance, its long life, and its resistance to fire. The lumber industry of the east was based upon white pine for much of the 1800s and early 1900s. Today, however (and due, in part, to exploitative logging), eastern white pine sawtimber is only locally important. In total, eastern white and red pines account for only about 3 percent of the volume of softwood growing stock in the U.S. In most areas of the East, eastern white pine is return-

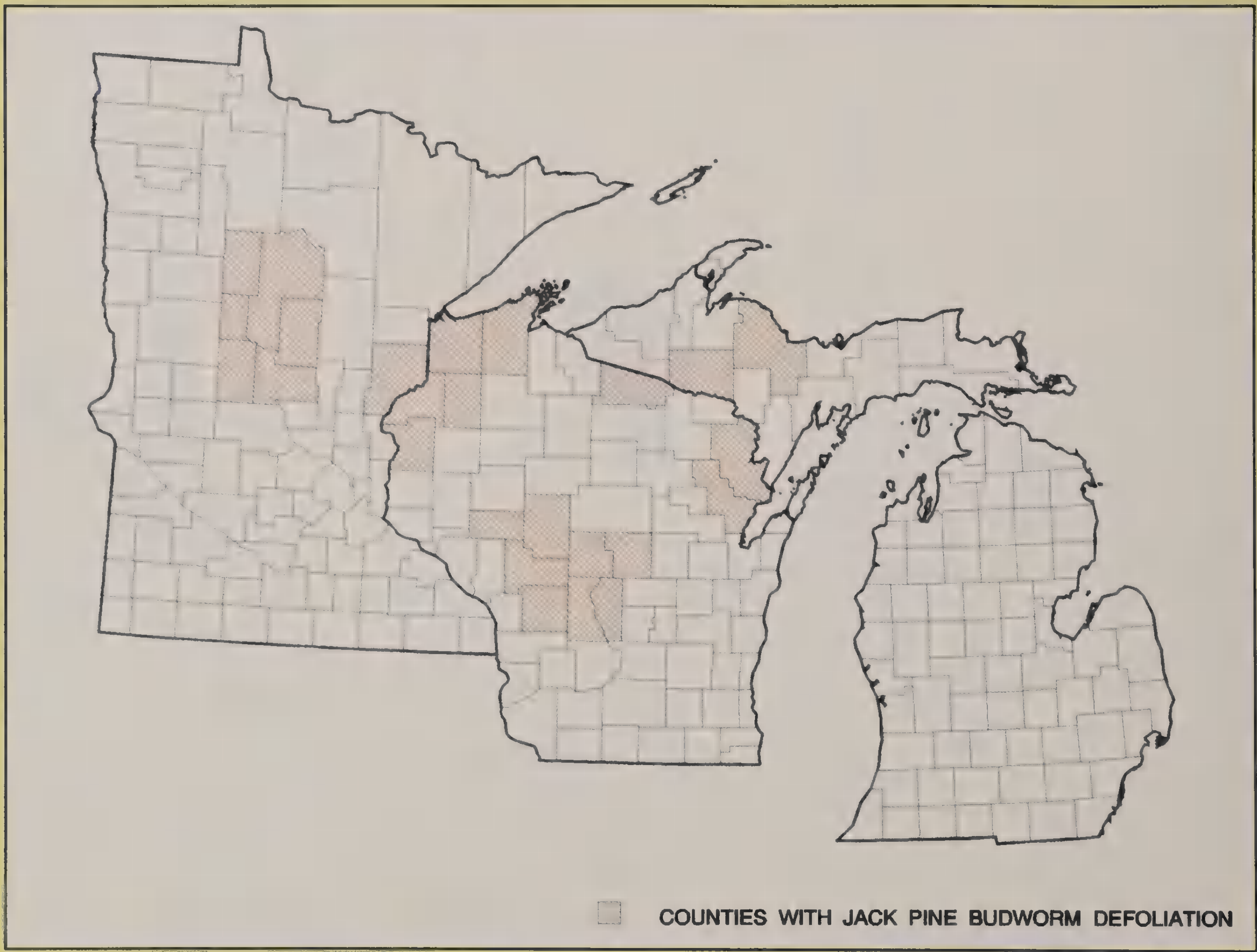


FIGURE I-9. *Jack pine budworm defoliation in 1993*

ing. Growing stock volumes are up 105 percent in West Virginia, 52 percent in Connecticut, and 43 percent in Pennsylvania, all in the last 20 years. Within the Northeastern Area, today, Michigan has the largest concentration of eastern white and red pines totaling an estimated 2,017 million cubic feet of growing stock, followed by Maine with 1,916, and New York with 1,809.

During recent years, planting of eastern white pine has not been pursued because of problems caused by white pine weevil and white pine blister rust. Blister rust is a fungus-caused, introduced disease. Control programs, once established throughout New England and the Lake States, have largely been abandoned. In Maine, the program continues with the removal of alternate host currant plants found growing near eastern white pine plantations. In 1993, nearly 5,000 acres of pine forest were scouted for currant plants with over 4,000 plants being removed.

The Forest Service has been involved in efforts to breed eastern white pine which are resistant to blister rust. Some successes have been noted. In addition, management techniques have been developed to help minimize the damage caused by blister rust.

White pine weevil has caused sporadic damage to white pine throughout the Northeastern Area, but has been particularly damaging to young pine plantations. Damage caused by the weevil is done by larvae boring under the bark of new shoots, especially the main terminal, causing abnormal shoot growth and shoot mortality.

Forest management practices can be used to help minimize weevil damage. This includes growing eastern white pine beneath an overstory since shade reduces attacks by the weevil. Weevil management also necessitates a periodic monitoring for damage.

White-tailed deer also have a significant impact upon white pine establishment. Repeated deer feeding injury is, in many areas, the greatest limiting factor in eastern white pine establishment.

Monitoring of eastern white pine on Forest Health Monitoring Plots in New England shows that overall eastern white pine crowns are in relatively good condition.

White pine weevil damage to shoot of white pine sapling.

White pine crown condition on New England Forest Health Monitoring Plots 1993

	PERCENT OF TREES
CROWN DIEBACK	
none-light	**99.0**
moderate-severe	**1.0**
CROWN DENSITY	
good-average	**98.5**
poor	**1.5**

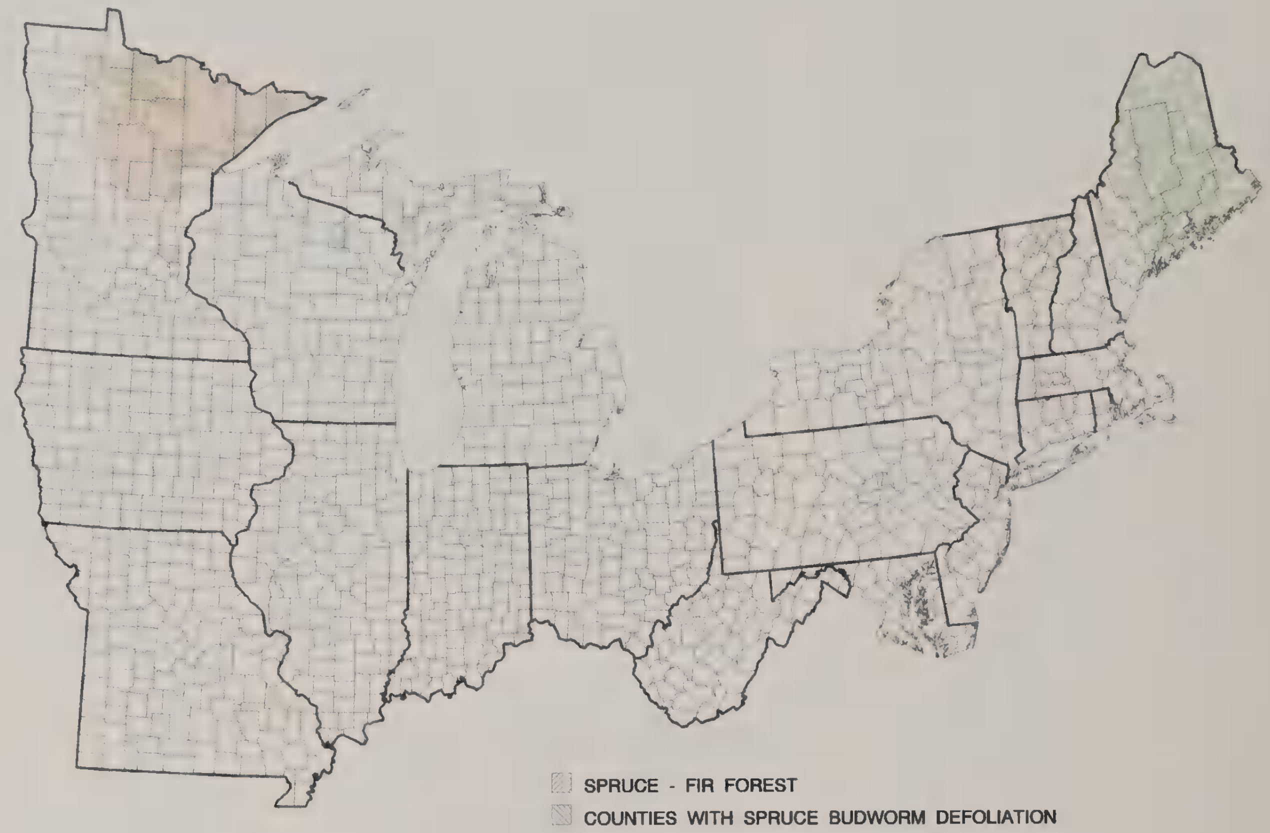


FIGURE I-10. *Eastern spruce budworm defoliation in 1993 and the distribution of spruce-fir forests.*

SPRUCE & BALSAM FIR

By far, the largest volumes of spruce and fir occur in the states of Maine, New Hampshire, New York, Vermont, West Virginia, Michigan, and Minnesota. Several types of spruce occur in the eastern United States. Red spruce is restricted to the Appalachian Mountains, the Adirondacks, northern Maine, and adjacent areas. Red spruce occurring with balsam fir is often found in montane environments and forms one of the striking ecological features of the mountains of the eastern United States. Black and white spruce are found primarily in the Lake States.

In recent years, low elevation spruce-fir forests below 2,600 feet have been affected by the eastern spruce budworm, a defoliator of both spruce and fir. During the 1970s and 1980s, hundreds of thousands of acres of spruce-fir forests in New England and the Lake States were defoliated repeatedly by this insect. Balsam fir is the preferred host. Stress caused by these outbreaks took a toll on the New England spruce-fir forests where they occurred and undoubtedly was responsible for some of the loss in fir witnessed in Maine and New Hampshire. However, no significant budworm activity has been detected during the last couple of years in New England. In 1993, defoliation caused by this insect was reported in Minnesota (Figure I-10).

Forest inventory data for the years 1973-1990 show that balsam fir growth has been generally positive except in New Hampshire and Maine. In Maine, for the years 1973-1983, balsam fir growth, as a percent of total fir growing stock, showed a 2 percent net annual decrease; either through cutting or mortality

Mortality in the spruce-fir forest on Mt. Washington, White Mountain National Forest, New Hampshire.

caused by extensive spruce budworm defoliation. While in Michigan and Wisconsin, for roughly the same years, balsam fir gained an estimated 2 percent per year. Balsam fir growth has also been positive in Minnesota, though less than in other Lake States.

During the same years, red spruce at both higher and lower elevations in Maine, New Hampshire, New York, and Vermont, gained in volumes, as did white and black spruce in Michigan and Minnesota. In New Hampshire, for example, red spruce showed an annual net growth as a percent of growing stock of 2 percent per year. White spruce in Michigan, Wisconsin, and Minnesota appears to be doing particularly well with net growth in inventory (after accounting for mortality and cutting) averaging 5 percent, 4.5 percent, and 4 percent, respectively, per year. In West Virginia, where spruce is only located at high elevation montane sites above 3,600 feet, did spruce volumes decline. Its annual net change in growing stock volumes was down nearly 2 percent per year.

Perhaps the most dramatic change in spruce forests has been the loss of area. For example, in the late 1880s, spruce forests covered an estimated 750,000 acres in West Virginia. By 1986, the

acres of spruce forest decreased to about 110,000 acres. Some of this loss in spruce was due to heavy logging pressure and fires in the early 1900s, and replacement by hardwood species. Another concern in the West Virginia montane spruce forests is the apparent reduction in growth rates. Several investigators have noted less than expected growth during the years 1960 to 1980. Although drought has possibly played a role, some concern has been raised about the possibility of air pollution or acid rain contributing to the decline of spruce in West Virginia.

Crown data collected on Forest Health Monitoring Plots in New England in 1993 indicate average or good crown density on almost all trees with about 90 percent of balsam fir and red spruce trees having less than 5 percent dieback.

AIR POLLUTION AND HIGH ELEVATION SPRUCE FORESTS

High elevation or montane spruce-fir forests comprise only a-part of the forests dominated by spruce or fir. For example, 40 percent of northern New England and New York forest land has been classified as "spruce-fir", yet only 10 percent of this area is high-elevation spruce. During the 1970s and 1980s, large numbers of dead and declining red spruce at high-elevations throughout the Adirondacks and northern Appalachians caused concern.

An aerial photography survey was conducted by the Forest Service in the mountains and surrounding areas of northern New England and New York in the mid-1980s. About one-third of the 700,000 acres of spruce-fir forest land surveyed was classified as having greater than 30 percent standing dead spruce and fir. Most of these areas were located at the higher elevations above 2,600 feet.

Much research was carried out to uncover causes of this decline. During a 6-year period in the late 1980s, the National Acid Precipitation Assessment Program spent 16 million dollars involving more than 120 investigators from different institutions to examine red spruce forests in the eastern U.S. Results from this massive effort include:

- there is evidence of growth reduction of high elevation montane red spruce in the Adirondacks and northern and southern Appalachians.

- field and laboratory tests support the conclusion that acidic cloud water has played a role in decline of high elevation red spruce in the northeastern U.S.

- winter injury is clearly associated with decreased growth and increased tree mortality in the Northeast, while chemical imbalances in the soil increased by acidic deposition is also occurring.

- environmental stresses such as high winds, winter temperatures, and pests such as bark beetles, dwarf mistletoe, and stem and root diseases have played a role in the observed decline and mortality. This is supported by the Forest Service tree condition trend survey conducted from 1985 to 1989 in New England, New York, and West Virginia to describe crown and stem symptoms and to identify damage agents.

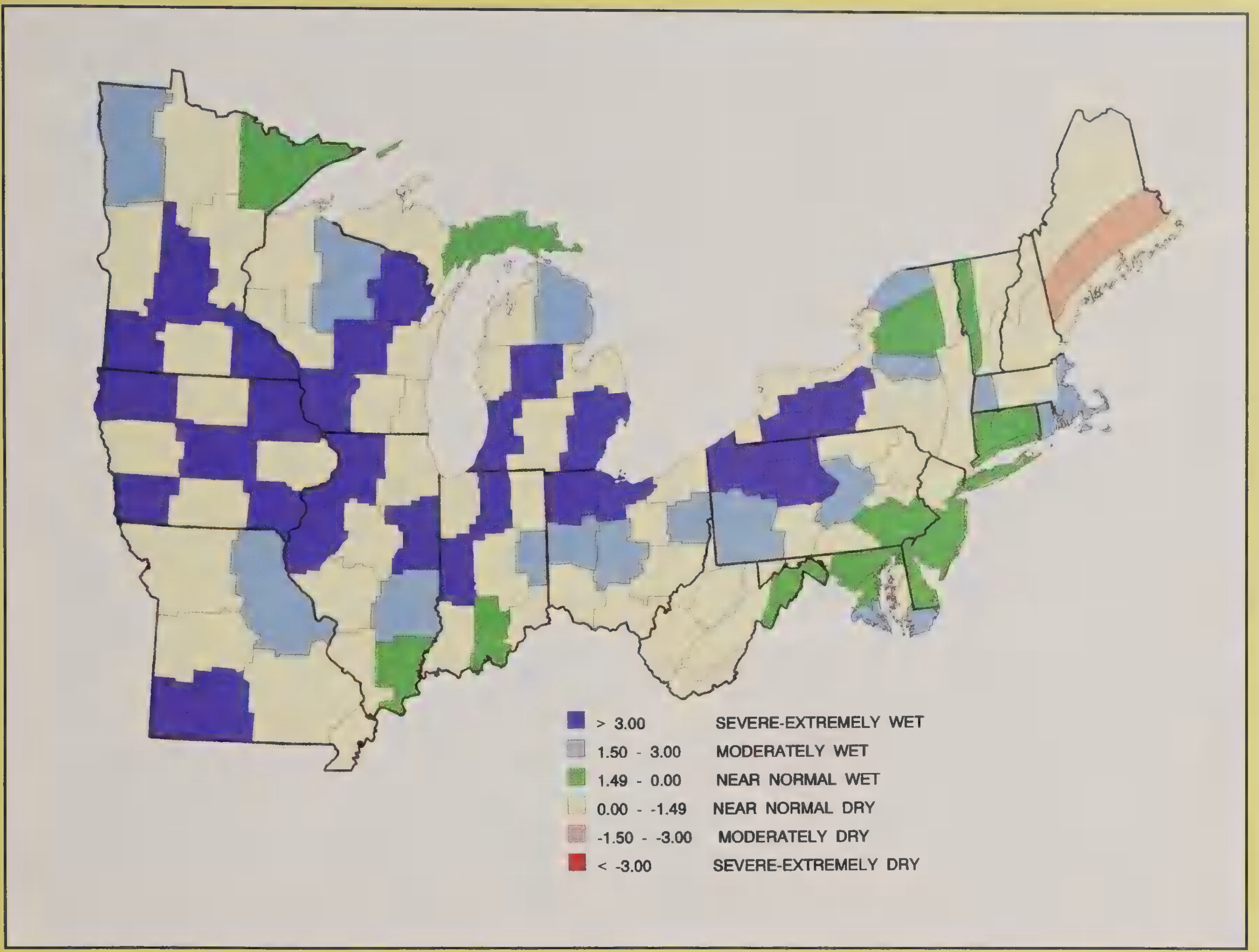


FIGURE I-11. *Average Palmer Hydrologic Drought Index, 1993, by climate division.*

WEATHER

In the summer of 1993, there were vast contrasts in weather conditions across the Northeastern Area. In the East, there were severe drought conditions, while in the Midwest, extensive flooding occurred brought on by extensive and persistent rain (Figure I-11). These extremes lead to different responses and damage to various forest tree species.

In the dry East, leaves discolored early and dropped prematurely. Several species were especially affected, such as birch. In contrast, in the Midwest, thousands of acres of bottomland hardwood areas were flooded for 4 to 12 weeks. The flood waters also backed up into upland areas, affecting urban areas forested with trees not well adapted to flooding. The states along the Missouri and Mississippi Rivers and their tributaries were severely affected (Figure I-12). Flood stressed trees exhibited a range of symptoms including leaf yellowing, early leaf drop, and dieback. It is possible that these affected trees will show symptoms for several years.

The impact of flooding on trees varies. Flooding results in poor soil aeration, alters the pH of the soil, and reduces the decomposition of organic matter. In addition, sedimentation of silt and sand is deposited as well as soil being eroded away. Individual characteristics of trees affect their flood tolerance. Tree injury increases with the amount of crown covered by water and the duration. Dominant trees which are not over mature are more tolerant, though long-term flooding can lead to death of the trees' root system.

Some trees have a greater overall tolerance to flooding such as eastern cottonwood, sycamore,

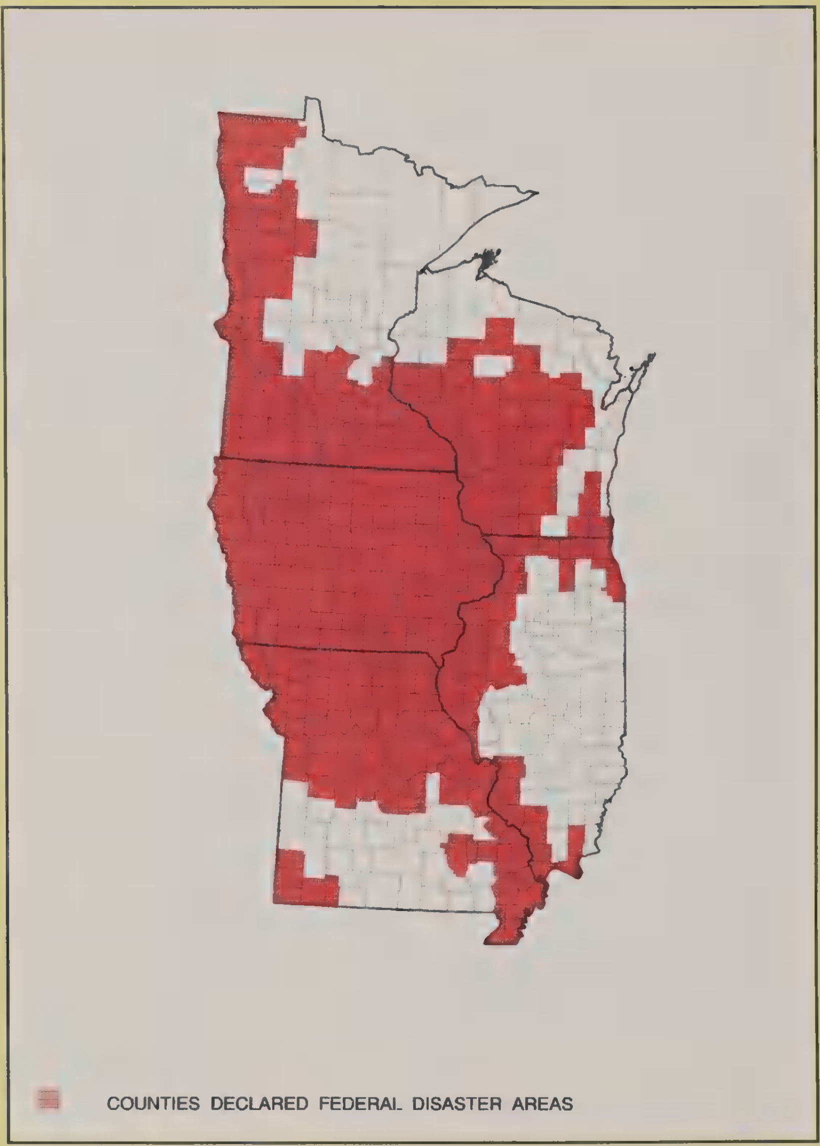


Figure I-12. *Counties declared Federal Disaster Areas as a result of extensive flooding, 1993.*

Winter browning of needles on red spruce.

and willow, as opposed to sugar maple, northern red and white oak, hickory, and various conifers. Flood tolerance is dependent upon season of flooding, duration, water temperature, mechanical injury from debris, and the effect of chemical runoff. Insect and disease impacts may occur, especially from stem borers and root diseases, as trees are stressed by flooding. Tree recovery is relative to all of these various factors. As a result of the "once-in-a-lifetime" floods of 1993, there will be many affected stands and probably an overabundance of seeds produced. There may also be continued mortality as trees are affected by additional factors. There are, however, some positive effects from flooding. In some of the more tolerant species, growth can be greatly increased from the excess amount of water.

In early 1993, severe winter weather also caused tree damage in the Northeast. The most dramatic was the browning of red spruce, which occurred extensively over several thousand acres throughout New York, northern New England, and the Berkshire Mountains of Massachusetts. Since the most recent year's foliage was mainly affected, extensive mortality is not expected, although repeated years of winter injury causes dieback which is a contributing factor to spruce mortality in certain stands. The damage was most severe at higher elevations in mountainous terrain, but lowland spruce stands were also affected.

Flooding of the Mississippi River in St. Louis, Missouri. Composite of satellite images from 1991, showing the original river channel, and 1993, indicating the extent of the flooding. (©1994 CNES. Provided by SPOT Image Corporation)

Oak wilt infection site in St. Paul, Minnesota.

URBAN FORESTRY FACTS

- **Four trees are dying for every one planted.**
- **The average life span of a downtown city tree is seven years.**
- **Urban trees are rarely visited more than twice in their lifetime—once at planting and once at removal.**
- **Urban soils have been significantly altered—they are often composed of a variety of debris and rubble that changes the soil chemistry and pH.**
- **Dutch Elm Disease spread rapidly through our cities because we lined our streets with a single species of tree—the American Elm.**
- **Dogwood anthracnose continues to spread—in 1993, it was reported as far north as Maine (Figure I-13).**
- **Oak wilt control has been implemented in some cities to control spread of the disease from tree to tree on home owners' property.**
- **Hemlock woolly adelgid continues to spread—it is a serious but controllable problem in ornamental landscapes.**

URBAN FORESTS

The concept of urban forestry conjures up all kinds of thoughts. For some, the term is difficult to relate to since the native forest has disappeared from urban areas, for others it means tree planting in cities. In terms of forest health it is the art and science of long-term care of plants in communities. Most would agree on the importance of vegetation in the places that we live and its contribution to our quality of life. However, many of the benefits received from urban vegetation such as cooling, aesthetics, and cleaner air, are taken for granted. Unless more attention is paid to the health of the urban forest, the prognosis is not good.

During the late 1980s, while preparing the 1990 Farm Bill in Congress, reports indicated that the health of forests in urban areas and communities, including cities, their suburbs, and towns in the United States, was on the decline. This trend is not apt to change unless we significantly alter the way we manage urban forests, or more accurately the way we plan for and implement urban development. Providing room for a fully functioning, dynamic ecosystem within a maze of highways, sidewalks, buildings, and utilities is the key to a healthy, long-lived urban forest that continually provides us with a multitude of benefits.

The urban forest faces a myriad of problems, from human activity to insect and disease problems. It is imperative that we act appropriately to maintain and protect their health. To improve the quality of the forest in which we live, the urban and community forestry program must channel

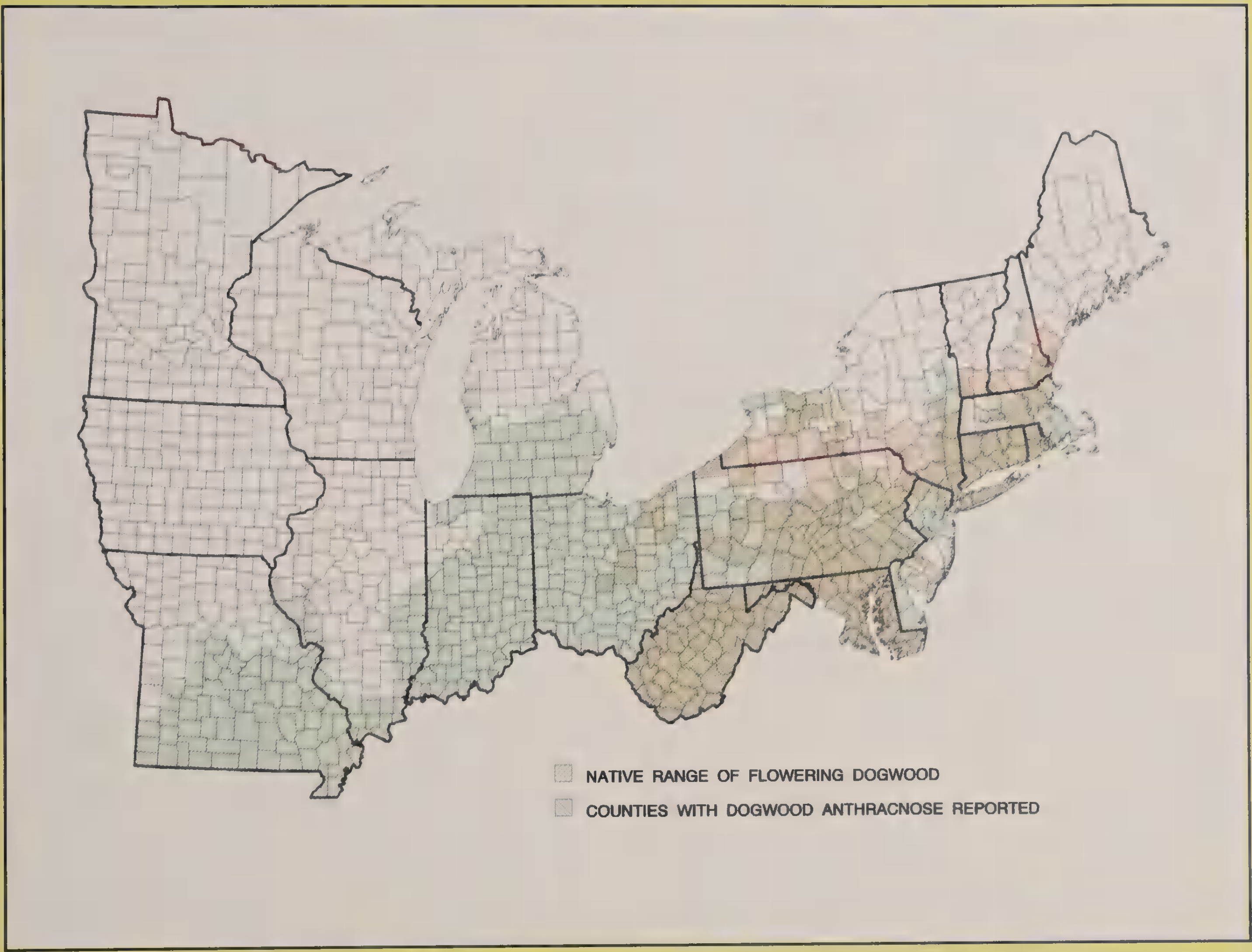


FIGURE I-13. *Distribution of dogwood anthracnose in 1993 and the native range of flowering dogwood.*

some of the public's current enthusiasm and energy for tree planting into stewardship and maintenance of our urban forest. We must encourage and support citizens who take an active role in monitoring the health of their urban forest.

We continue to see some of the same insect and disease problems affecting urban trees which affect forest trees, including hemlock woolly adelgid, oak wilt, gypsy moth, Dutch elm disease, and dogwood anthracnose. The biggest impact on the health of the urban forests comes from human activity. We can save money, reduce the potential for future hazards, and promote healthier trees by following some basic guidelines for establishing and maintaining a vital urban forest. These include being aware of the growing site, planting healthy diverse stock, being aware of the latest growing techniques, and proper pruning and mulching. The best way to insure long-term health of trees and plants is during the planning and planting stages of the urban forest.

In 1990, the Northeastern Area developed a 5-year plan for urban forestry in the Northeast, Midwest, and District of Columbia. The Urban and Community Forestry Program is administered by a state coordinator and council, which works together with volunteers to implement an urban forestry plan in each state. There are various program components including: pilot state activities, Congressional projects, special urban projects, and other state and federal programs. Under the federal program, three urban forestry centers were established in Chicago, Illinois; Philadelphia, Pennsylvania; and Amherst, Massachusetts, to enhance urban forestry technology transfer, encourage better urban woodland management, and promote appropriate plant health care and pest diagnosis.

A major activity of Urban and Community Forestry is the Hazard Tree Program, which provides training to forest managers to recognize and manage hazard trees. Another major component is Plant Health Care, part of a national campaign with the National Arborist Foundation and the International Society of Arborculture, that stresses a holistic approach to plant care. In addition, pest information publications are developed to assist in urban forest health monitoring efforts and diagnostic laboratories have been funded. States are integrating monitoring tree condition standards into urban tree health surveys. A major project under urban pest management is the oak wilt suppression program in Minnesota. This 5-year program was implemented in 1992 to treat infection centers within the Minneapolis/St. Paul area and carry out an intensive educational program.

FOREST STEWARDSHIP PROGRAM

There are approximately 111 million acres of forest land owned by private landowners in the Northeastern Area. The overall health of the forests of the Northeast is somewhat dependent on the management activities of these numerous private landowners. The goal of the national stewardship program is to place non-industrial private forest lands under stewardship management, to apply resource management practices for future benefit. The program, which began in 1990, is well under way in the northeastern states (Table I-4). About 2.5 million acres were placed under stewardship management in these states by 1993, in an effort to maintain and enhance eastern forests.

Each state, under the leadership of the State Forester, has established a State Stewardship Committee, which includes representatives from forestry, fish and wildlife, soil and water, and recreation. Through this program, training and management information is provided to the private landowner. In addition, forest health and fire protection considerations are incorporated into management guidelines and plans. The program also reaches out through the media in attempt to develop a forest stewardship ethic among the general public.

Table I-4. *Forest stewardship program in the Northeastern Area, 1990 through 1994.*

	ACRES ADDED TO STEWARDSHIP PROGRAM				
STATES	1990	1991	1992	1993	*Target for* 1994
CT	0	0	5,003	5,192	18,500
DE	0	3,750	581	5,829	4,000
IL	11,204	61,708	45,294	29,606	45,000
IN	52,585	17,158	15,462	35,188	46,400
IA	4,440	13,800	27,314	23,547	17,250
ME	0	4,717	27,818	36,350	102,000
MD	5,965	7,148	31,090	24,353	26,500
MA	20,390	22,276	4,515	19,390	30,500
MI	147	6,000	1,444	46,320	112,600
MN	56,382	24,648	96,850	79,949	67,600
MO	28,971	38,936	25,519	17,901	124,500
NH	21,600	48,418	37,615	55,462	41,100
NJ	0	0	828	8,656	17,250
NY	112,445	117,993	79,712	163,552	167,000
OH	39,984	34,726	76,335	76,557	84,800
PA	0	0	2,428	27,045	145,700
RI	0	826	1,812	1,270	4,000
VT	1,350	24,930	14,067	21,800	42,400
WV	30,286	35,800	51,281	54,377	116,600
WI	41,312	113,792	110,184	94,278	111,300
TOTAL	427,061	576,626	655,152	826,622	1,325,000

Section Two

Forest Health Monitoring Plot Network in the New England & Mid-Atlantic States

1993 SUMMARY

In 1993, the Northern Forest Health Monitoring Program collected data from over 6,500 trees on 256 plots in Delaware, Maryland, New Jersey, Massachusetts, Rhode Island, Connecticut, Vermont, New Hampshire, and Maine. There continues to be no evidence of large, regional-scale declines in forest ecosystem health as determined by observations of visual crown indicators on trees, e.g. crown dieback, crown density, and foliage transparency. The proportion of eastern hemlock with severe levels of crown transparency is less in 1993 than in 1992, but the proportion of hemlock with severe dieback has increased, possibly as a result of defoliation in 1992 leading to dieback in 1993. Approximately 20 percent of all trees have some kind of currently existing damage condition, such as decay indicators or open wounds. Symptoms of ozone exposure were noted on ozone sensitive plants on 10 of 98 plots where the bioindicator plants were found.

OBJECTIVES

The Northern Forest Health Monitoring Program was initiated in 1990 to provide for a long-term, systematic collection of scientifically sound information on the condition of forested ecosystems. This program in the Northeast is a continuing, cooperative effort among the USDA Forest Service, U.S. Environmental Protection Agency, and the various state departments and agencies which deal with forested ecosystems. The Northeastern Forest Experiment Station has overall responsibility for activities on the plots and is assisted by the Northeastern Area, State and Private Forestry, Forest Health Protection staff. The EPA Environmen-

tal Monitoring and Assessment Program for forests (EMAP-Forests) provides specific assistance in sampling design, training and quality assurance activities, electronic data collection procedures, and research on additional indicators of forest health and condition. The State Foresters in cooperating states provide the services of their staffs to cooperate in developing and managing the program, and in collecting data.

The objectives of the program relating to the plot network are to:

1. Estimate the current status, extent, changes, and trends in forest ecosystem health with known confidence;

2. Monitor indicators of forest tree and ecosystem condition and identify associations between natural and human-caused stresses and ecological condition;

3. Provide periodic statistical summaries and interpretative reports on the ecological status and trends to resource managers and the public.

1993 ACTIVITIES

In 1993, the Forest Health Monitoring Program in the Northeast involved six New England states (Maine, Vermont, New Hampshire, Massachusetts, Connecticut, and Rhode Island) and three Mid-Atlantic states (New Jersey, Maryland, and Delaware). The New England states were implemented in 1990 and the Mid-

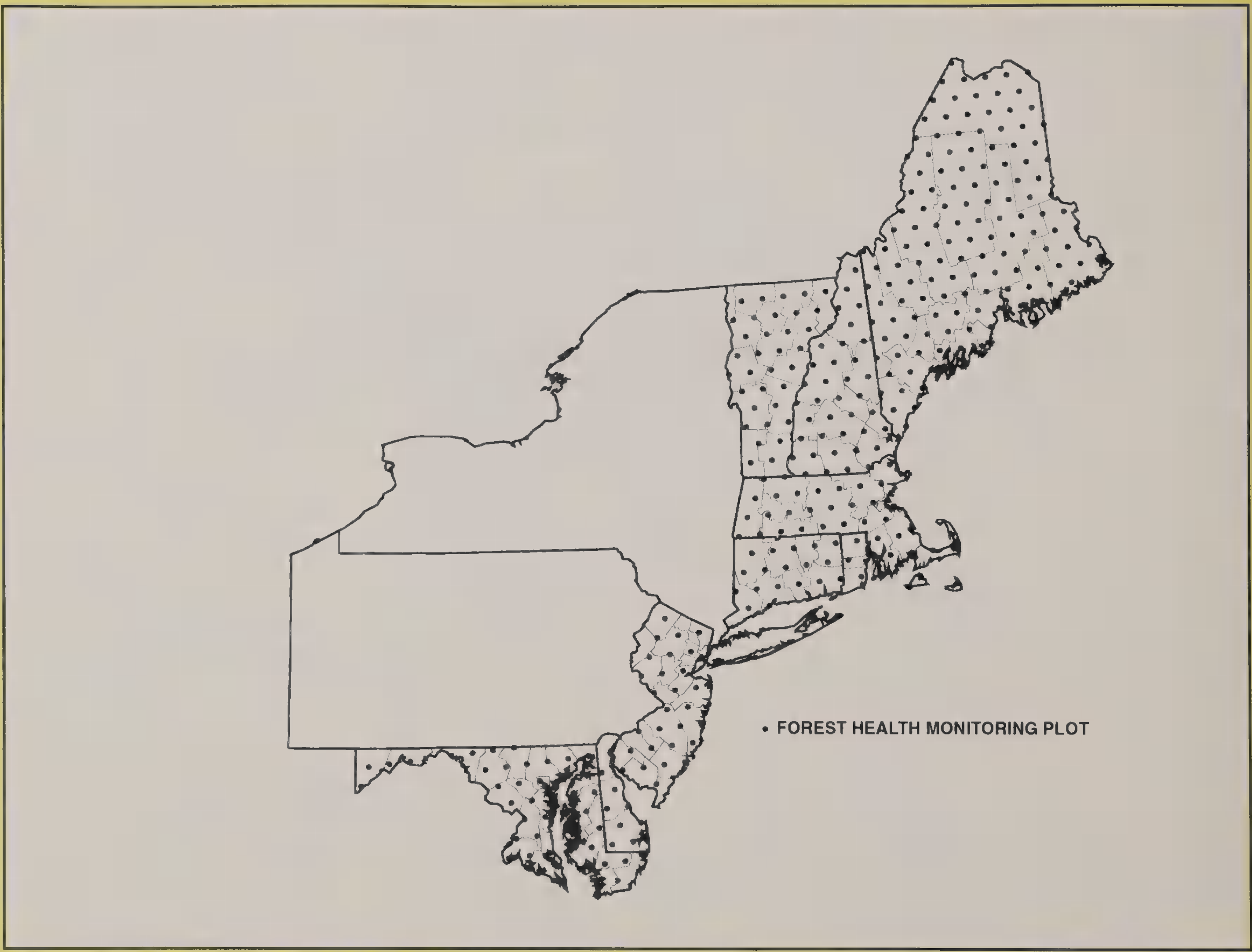


FIGURE II-1. *Distribution of Forest Health Monitoring Plots in the New England and Mid-Atlantic States.*

Branch dieback in the upper crown of sample trees within a Forest Health Monitoing Plot.

Atlantic states were added one year later. In the Northeast, tree crown and damage measurements were taken on all forested plots. The sample consists of 222 plots with 5848 trees in New England, and 34 plots with 719 trees in the Mid-Atlantic states (Figure II-1). Observations on ozone sensitive plants were taken on 98 forested plots where appropriate sampling conditions existed. Field measurements are based on estimates of trained observers, and a rigorous quality assurance program insures that measurements are unbiased and of consistently high quality (Appendix II).

This report includes summaries of three indicators of crown vigor: foliage transparency, crown dieback, and crown density. All crown measurements were made by using the same procedures as in 1992. Observations of tree damage by various agents, and observations of symptoms of ozone exposure on sensitive plant species, are also discussed.

In previous years the Forest Health Monitoring Plot summary reports included the larger (dominant and codominant) trees in the sample population. This year, all live trees in the sample are included , in order to provide a more comprehensive snapshot of the forested ecosystem. Previous years' estimates included in this report were recomputed to reflect inclusion of all trees which were alive in that particular year.

TREE CROWN MEASUREMENTS

Three different measurements on crowns are collected for trees greater than five inches in diameter. *Foliage transparency* is an estimate of the amount of skylight visible through the foliated portion of a tree crown. The amount of foliage transparency differs by species and depends on the branching pattern plus the type and orientation of leaves. Foliage transparency serves as an estimator of defoliation caused by insect damage, pathogens, or environmental stress.

Crown dieback is defined as recent branch mortality that begins at the terminal portion of branches and proceeds toward the trunk. Dead branches in the center and lower crown or below the live crown are assumed to have died from competition or shading and are not included. Crown dieback is caused by severe stress, frequently to the root system of the tree, though some species exhibit light levels of dieback as part of their normal growth and development.

Crown density represents the amount of foliage, reproductive structures (e.g., seeds or cones), and branches that obstruct skylight visibility through the crown. A normal, healthy, forest-grown tree is used as the standard. A dead top is included but dead lower branches are excluded. Estimates of low crown density have been correlated with reduced tree growth for several species.

Foliage Transparency

There has been minimal change in overall foliage transparency throughout New England since 1990. About 98.7 percent of trees greater than 5 inches in diameter were classified as having normal (greater than 30 percent) foliage transparency in 1993, compared to 97.3 percent and 93.3 percent in 1992 and 1991 respectively (Table II-1). Eastern hemlock had 6.7 percent of the trees in the moderate and severe classes, down from 8.6 percent in 1992. This is consistent with an observed reduction in defoliation associated with the hemlock looper in 1993 relative to 1992. Northern white-cedar had 1.2 percent of the trees in the moderate and severe classes, down from 6.1 percent in 1992 and 14.9 percent in 1991.

Crown Density

Approximately 98 percent of trees were evaluated as having good or average crown densities (density greater than 20 percent) in New England (Table II-2). Hardwoods had a slightly higher percentage of trees classified as average or poor than softwoods. Eastern hemlock had 5.0 percent of the trees in the less than 20 percent density class, up from 3.7 percent in 1992. One possible explanation for this is that defoliation caused by the hemlock looper in 1992 resulted in dieback of the crown by 1993 on some of the population. All other common species had less than 4 percent of the trees in the less than 20 percent density class.

Crown Dieback

About 96.5 percent of trees evaluated on Forest Health Monitoring Plots in New England in 1993 were classified as having no or light crown dieback, with less than 20 percent dieback, nearly the same as 1990-1992 (Table II-3). Once again hardwoods tend to have more crown dieback than softwoods. Eastern hemlock had 7.5 percent of the trees in the moderate or severe classes, compared to 0.5 percent in 1992. This may illustrate the effects of multiple year defoliation.

Table II-1. *Distribution of live trees of major species on Forest Health Monitoring Plots in New England, by foliage transparency class, 1993.*

		PERCENT OF SAMPLED TREES		
SPECIES	NUMBER OF TREES	NORMAL (0-30%)	MODERATE (31-50%)	SEVERE (51+%)
All species	5,848	98.7	0.8	0.8
Softwoods	2,618	98.4	0.8	0.8
Hardwoods	3,230	98.9	0.9	0.2
Balsam fir	553	99.8	0.2	0.0
Red spruce	656	99.7	0.0	0.3
Eastern white pine	521	98.8	1.0	0.2
Northern white cedar	346	98.8	1.2	0.0
Eastern hemlock	401	93.3	2.5	4.2
Red maple	946	98.9	0.7	0.2
Sugar maple	439	99.5	0.5	0.0
Yellow birch	268	98.9	0.8	0.4
Paper birch	310	98.4	1.3	0.3
American beech	229	98.4	2.2	0.4
White ash	162	98.2	1.2	0.6
Northern red oak	196	99.0	0.5	0.5

Table II-2. *Distribution of live trees of major species on Forest Health Monitoring Plots in New England, by crown density class, 1993.*

SPECIES	NUMBER OF TREES	PERCENT OF SAMPLED TREES GOOD (51+%)	AVERAGE (21-50%)	POOR (1-20%)
All species	5,848	45.3	52.7	2.0
Softwoods	2,618	46.7	51.4	1.9
Hardwoods	3,230	44.1	53.7	2.2
Balsam fir	553	52.6	47.0	0.4
Red spruce	656	54.1	45.1	0.8
Eastern white pine	521	37.1	61.4	1.5
Northern white cedar	346	42.8	53.7	3.5
Eastern hemlock	401	37.7	57.3	5.0
Red maple	946	34.7	62.9	2.4
Sugar maple	439	56.7	42.4	0.9
Yellow birch	268	57.1	41.4	1.5
Paper birch	310	51.9	46.5	1.6
American beech	229	42.4	53.7	3.9
White ash	162	37.6	59.3	3.1
Northern red oak	196	41.3	57.7	1.0

Table II-3. *Distribution of live trees of major species on Forest Health Monitoring Plots in New England, by crown dieback class, 1993.*

SPECIES	NUMBER OF TREES	PERCENT OF SAMPLED TREES NONE (0-5%)	LIGHT (6-20%)	MODERATE (21-50%)	SEVERE (51+%)
All species	5,848	78.1	18.4	2.3	1.2
Softwoods	2,618	88.5	8.8	1.3	1.4
Hardwoods	3,230	69.7	26.2	3.1	1.0
Balsam fir	553	89.0	9.8	0.7	0.5
Red spruce	656	91.4	7.5	0.9	0.2
Eastern white pine	521	91.7	7.3	0.6	0.4
Northern white cedar	346	81.8	12.7	3.2	2.3
Eastern hemlock	401	83.0	9.5	1.8	5.7
Red maple	946	69.0	27.2	3.0	0.8
Sugar maple	439	82.5	16.0	1.1	0.5
Yellow birch	268	77.3	19.0	2.6	1.1
Paper birch	310	61.3	33.8	4.2	0.7
American beech	229	61.6	31.4	4.8	2.2
White ash	162	65.4	27.8	4.9	1.9
Northern red oak	196	66.8	31.1	1.5	0.5

Foliage Transparency

About 98 percent of trees were classified as having normal foliage transparency in 1993, compared to 99 percent in 1992 (Table II-4). No species had more than 3 percent of the trees in the moderate or severe classes.

Crown Density

Only 1.8 percent of all trees were classified as having crown density less than 20 percent (Table II-5). Hardwoods generally had higher crown densities than softwoods. Pitch pine had 3.3 percent of trees in the less than 20 percent class, down from 6 percent in 1992. All other species had less than 3 percent of trees in that class.

Crown Dieback

Virtually all (99.2 percent) of the trees were classified as having either no or light crown dieback, with less than 20 percent dieback (Table II-6). No single species had more than 2 percent in the moderate or severe classes.

TREE DAMAGE MEASUREMENTS

Damage caused by pathogens, insects, weather extremes, or other agents can adversely affect tree health, either by killing trees or by reducing the growth or development. Information is collected on up to three types of damage per tree, limiting observations to certain types of damage which may potentially either kill the tree or adversely affect long term survival. For each damage the location of where it occurs is also recorded, along with an assessment of the degree of severity.

Types of damage recorded include:

- canker—an area of dead tree tissue, often caused by disease
- decay indicator—conks or other evidence of advanced wood decay
- open wound—area where bark has been removed, exposing inner wood
- resinosis—area of sap exudation on trunk or branches
- broken limbs, roots, branches, or tree crowns
- brooms—clusters of foliage about a single point
- damaged foliage or shoots
- discolored foliage
- other damage not listed above but deemed to put tree at risk

A certain amount of damage in the

Table II-4. *Distribution of live trees of major species on Forest Health Monitoring Plots in New Jersey, Delaware, and Maryland, by foliage transparency class, 1993.*

		PERCENT OF SAMPLED TREES		
SPECIES	**NUMBER OF TREES**	**NORMAL (0-30%)**	**MODERATE (31-50%)**	**SEVERE (51+%)**
All species	**719**	**98.0**	**1.6**	**0.4**
Softwoods	**166**	**98.2**	**1.2**	**0.6**
Hardwoods	**553**	**98.0**	**1.6**	**0.4**
Pitch pine	**90**	**97.8**	**1.1**	**1.1**
Loblolly pine	**40**	**97.5**	**2.5**	**0.0**
Red maple	**96**	**97.9**	**2.1**	**0.0**
Sweetgum	**56**	**100.0**	**0.0**	**0.0**
Black cherry	**37**	**97.3**	**2.7**	**0.0**

Table II-5. *Distribution of live trees of major species on Forest Health Monitoring Plots in New Jersey, Delaware, and Maryland, by crown density class, 1993.*

		PERCENT OF SAMPLED TREES		
SPECIES	NUMBER OF TREES	GOOD (51+%)	AVERAGE (21-50%)	POOR (1-20%)
All species	719	50.5	47.7	1.8
Softwoods	166	34.3	63.3	2.4
Hardwoods	553	55.3	43.1	1.6
Pitch pine	90	23.3	73.3	3.3
Loblolly pine	40	52.5	45.0	2.5
Red maple	96	55.2	42.7	2.1
Sweetgum	56	58.9	41.1	0.0
Black cherry	37	64.9	35.1	0.0

Table II-6. *Distribution of live trees of major species on Forest Health Monitoring Plots in New Jersey, Delaware, and Maryland, by crown dieback class, 1993.*

		PERCENT OF SAMPLED TREES			
SPECIES	NUMBER OF TREES	NONE (0-5%)	LIGHT (6-20%)	MODERATE (21-50%)	SEVERE (51+%)
All species	719	92.2	7.0	0.7	0.1
Softwoods	166	95.8	3.6	0.6	0.0
Hardwoods	553	91.1	8.0	0.7	0.2
Pitch pine	90	95.6	3.3	1.1	0.0
Loblolly pine	40	97.5	2.5	0.0	0.0
Red maple	96	92.7	6.3	1.0	0.0
Sweetgum	56	92.9	7.1	0.0	0.0
Black cherry	37	89.2	10.8	0.0	0.0

population of trees is expected and even desirable. For example, openings in trees are used as shelters by wildlife, and decaying wood harbors insects which are a critical part of the ecosystem food chain. The purpose of collecting data on tree damages is to establish a baseline of expected damage levels, against which future trends may be measured, and to provide tree-specific data useful in determining potential causes of decline based on measurements of other variables.

NEW ENGLAND REGION

Approximately 79 percent of the sample of 5,848 trees from New England did not show any measurable signs of damage (Table II-7). Hardwood species had slightly more damage than softwood species (28.3 percent and 12.9 percent, respectively). Overall, the most common damage noted was decay indicators (11.6 percent). Other common damages include broken crowns, open wounds, cankers, crown damage, and other unspecified damage, each with less than 5 percent of the total sample. In some cases trees had more than one damage recorded.

Northern white-cedar and eastern hemlock showed the most damage among common softwood species, with decay indicators more common in northern white-cedar (10.4 percent of trees) and broken crowns more common in eastern hemlock (9.7 percent of trees). Eastern white pine showed the least amount of softwood trees with damage (7.5 percent).

Most of the hardwood species showed more damage, particularly decay indicators (17.6 percent), broken crowns (5.4 percent), and open wounds (4.8 percent). Over 45 percent of the American beech in the sample showed some kind of damage, with decay indicators (27.5 percent), broken crowns (8.7 percent), and open wounds (11.4 percent) the most common damages. Red maple also had a relatively high rate of damage (31.4 percent), again with decay indicators as the most common damage (22.3 percent).

MID-ATLANTIC REGION

Approximately 79 percent of the 719 trees from the mid-Atlantic region did not show measurable signs of damage (Table II-8). Hardwood species had slightly more damage than softwood species (24.4 percent and 10.8 percent, respectively). Overall, the most common damage was decay indicators (14.0 percent). Other common damages include broken crowns, open wounds, cankers, crown damage, and other unspecified damage, each with less than 3 percent of the total sample. Some trees had more than one damage noted.

Among softwood species, 3.0 percent had decay indicators and 3.6 percent had cankers. Cankers affected 5.6 percent of the pitch pine in the sample; no other damage affected more than 4 percent of the sample of pitch or loblolly pine.

Decay indicators were more common among hardwood species (17.4 percent of all trees). Red maple had the highest incidence of damage (35.4 percent of trees showed some damage and 30.2 percent of trees had decay indicators). Sweetgum had 8.9 percent of trees with decay indicators. Decay indicators were not recorded for black cherry, however 2.7 percent of the trees showed evidence of canker.

OZONE BIOINDICATOR PLANTS

Certain plants exhibit distinct foliar symptoms when exposed to specific air pollutants. Ozone is a regional gaseous air pollutant which at time reaches levels known to injure sensitive species (bioindicators plants), under appropriate environmental conditions. Ozone damage is a cumulative effect where symptoms commonly increase with increased exposure. The Northern Forest Health Monitoring Program includes surveys of plants known to be sensitive to ozone exposure. Symptoms of ozone damage are searched for when sensitive species are found in proximity to a plot, in stand openings selected according to a specified sample rule. This allows further classification of the stresses to which the ecosystem may be subjected. Sensitive plant species used as bioindicators in the Northeast include blackberry, milkweed, black cherry, white ash, white pine, and sweetgum.

Attempts are made to locate an ozone biomonitoring site near each forested plot. The biomonitoring site must be within one-quarter mile of the forested plot, and is ideally an opening greater than one-half acres in size. In this opening, plant species are examined which are known to show visible response to ozone exposure (typically a purplish stippling of the upper surface of leaves exposed to direct sunlight). The number of plants evaluated (up to 30) and the number of plants showing ozone symptoms are recorded.

In 1993 suitable biomonitoring sites were located on 98 of the 256 plots visited. Of the 98

Table II-7. *Types of damages noted on major species on Forest Health Monitoring Plots in New England, 1993. (Some trees had multiple damage.)*

		PERCENT OF SAMPLE TREES						
SPECIES	NUMBER OF TREES	NO DAMAGE	DECAY INDICATORS	BROKEN CROWN	OPEN WOUND	CANKER	CROWN DAMAGE	OTHER DAMAGE
All	5848	78.6	11.6	4.5	4.0	1.1	1.2	2.2
Softwood	2618	87.1	4.2	3.4	3.1	0.3	0.8	2.7
Hardwood	3230	71.7	17.6	5.4	4.8	1.7	1.5	1.8
Balsam fir	553	88.8	4.9	1.6	2.2	0.0	1.1	2.5
Red spruce	656	89.5	1.7	2.1	3.4	0.3	0.2	4.1
E. white pine	521	92.5	2.1	1.9	2.7	0.8	0.8	0.8
N. white cedar	346	80.6	10.4	4.3	5.2	0.0	1.2	1.7
E. hemlock	401	77.6	6.0	9.7	2.7	0.0	1.5	4.7
Red maple	946	68.6	22.3	6.4	5.1	0.7	0.7	1.5
Sugar maple	439	71.1	18.7	2.5	5.5	2.7	0.9	0.5
Yellow birch	268	72.0	16.0	4.5	4.1	3.4	1.9	4.9
Paper birch	310	71.6	13.5	7.1	5.5	0.3	2.6	1.0
American beech	229	54.6	27.5	8.7	11.4	4.8	1.3	1.3
White ash	162	79.0	11.7	4.9	3.1	0.0	1.2	1.9
N. red oak	196	89.8	6.6	1.5	0.5	0.5	1.0	1.0

Table II-8. *Types of damages noted on major species on Forest Health Monitoring Plots in New Jersey, Delaware, and Maryland, 1993. (Some trees had multiple damage.)*

		PERCENT OF SAMPLE TREES						
SPECIES	NUMBER OF TREES	NO DAMAGE	DECAY INDICATORS	BROKEN CROWN	OPEN WOUND	CANKER	CROWN DAMAGE	OTHER DAMAGE
All species	719	78.7	14.0	2.9	1.3	1.9	1.0	2.5
Softwood	166	89.2	3.0	0.6	0.6	3.6	1.2	2.4
Hardwood	553	75.6	17.4	3.6	1.4	1.4	0.9	2.5
Pitch pine	90	85.6	3.3	1.1	1.1	5.6	2.2	2.2
Loblolly pine	40	92.5	2.5	0.0	0.0	2.5	0.0	2.5
Red maple	96	64.6	30.2	3.1	2.1	1.0	0.0	3.1
Sweetgum	56	87.5	8.9	3.6	0.0	0.0	0.0	0.0
Black cherry	37	94.6	0.0	0.0	2.7	2.7	0.0	2.7

sites, ozone injury was observed at 10 sites. Blackberry, milkweed, and white ash were the species most often reported with ozone injury.

The regional distribution of the plots with ozone biomonitoring sites is shown in Figure II-2. Six of the positive ozone plots are located in Maryland, two in southern New England, and two in south-central Maine. These are all areas that are routinely designated as ozone-nonattainment areas by the U.S. Environmental Protection Agency. Over the past few years, the highest ozone values in the eastern US have been recorded in the mid-Atlantic states, which corresponds well with the 1993 plot data from the same area. The absence of positive ozone plots in New Jersey is attributed to the absence of ozone sensitive species on the forested plots in New Jersey.

The effects of ozone on sensitive plants is cumulative, with the symptoms becoming more obvious and more severe over time. Plots visited early in the field season are less likely to be scored positive than are plots visited later in the season. This confounds the data analysis, because plots are visited continuously throughout the summer by crews working within a given state. To correct this problem, the sampling window for biomonitoring has been reduced to a two week period in mid August for 1994 and future years. During this window, symptoms will be recorded on all plots where ozone biomonitoring sites are known to exist. More precise estimates of foliar injury will be collected, allowing better quantification of yearly fluctuations in degree of ozone exposure and stress at the plot and regional level.

Ozone injury symptoms on blackberry foliage.

Species found with ozone injury in 1993

SPECIES	NUMBER OF SITES	TOTAL NUMBER OF PLANTS	NUMBER OF PLANTS WITH SYMPTOMS	PERCENT OF PLANTS WITH SYMPTOMS
blackberry	49	1211	25	2.1
white pine	39	541	[illegible]	1.5
black cherry	25	309	0	0.0
milkweed	24	537	15	2.8
white ash	23	432	43	10.0
sweetgum	4	45	11	2.4

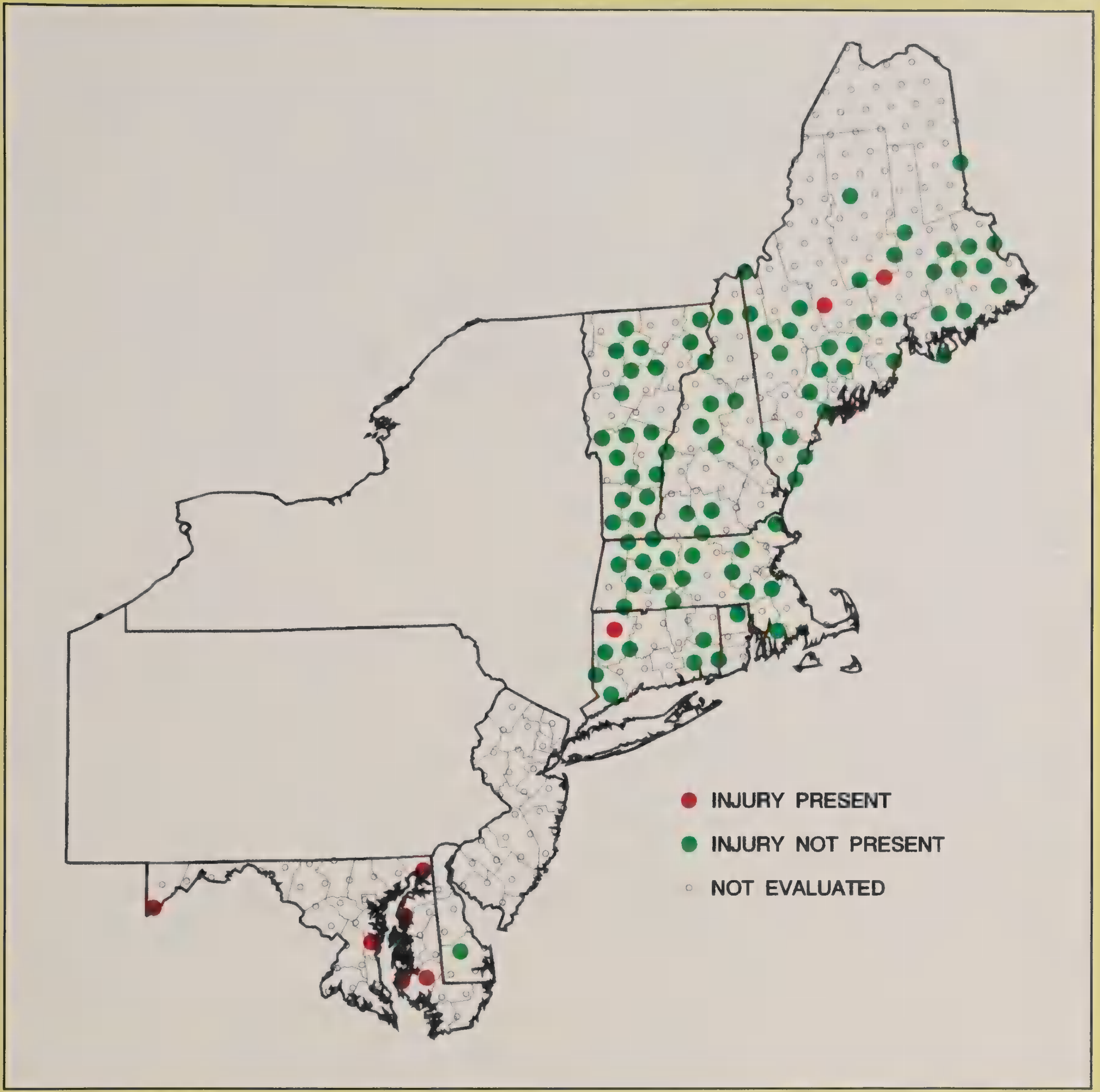


FIGURE II-2. *Forest Health Monitoring Plots with damage on ozone sensitive plants, 1993.*

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Appendix I

Common & Scientific Names for Plant Species, Insects, & Diseases

TREE SPECIES	SCIENTIFIC NAME
American basswood	*Tilia americana* L.
American beech	*Fagus grandifolia* Ehrh.
American chestnut	*Castanea dentata (*Marsh.) Borkh.
American elm	*Ulmus americana* L.
Aspen	*Populus* spp. L.
Ash	*Fraxinus spp.* L.
Balsam fir	*Abies balsamea* (L.) Mill.
Birch	*Betula spp.* L.
Black ash	*Fraxinus nigra* Marsh.
Black cherry	*Prunus serotina* Ehrg.
Black spruce	*Picea mariana* (Mill.) B. S. P.
Butternut	*Juglans cinerea* L.
Carolina hemlock	*Tsuga caroliniana* Englem.
Eastern cottonwood	P*opulus deltoides* Bartr. ex Marsh.
Eastern hemlock	*Tsuga canadensis* (L.) Carr.
Eastern white pine	*Pinus strobus* L.
Elm	*Ulmus spp.* L.
Flowering dogwood	*Cornus florida* L.
Fir	*Abies* spp. Mill.
Hickory	*Carya* spp. Nutt.
Jack pine	*Pinus banksiana* Lamb.
Loblolly pine	*Pinus taeda* L.
Maple	*Acer* spp. L.
Northern red oak	*Quercus rubra* L.

Northern white cedar	*Thuja occidentalis* L.
Norway maple	*Acer platanoides* L.
Oak	*Quercus spp.* L.
Paper (white) birch	*Betula papyrifera* Marsh.
Pine	*Pinus* spp. L.
Pitch pine	*Pinus rigida* Mill.
Red maple	*Acer rubrum* L.
Red pine	*Pinus resinosa* Ait.
Red spruce	*Picea rubens* Sarg.
Shortleaf pine	*Pinus echinata* Mill.
Spruce	*Picea* spp. A.Dietr.
Sugar maple	*Acer saccharum* Marsh.
Sweetgum	*Liquidambar styraciflua* L.
Sycamore	*Platanus occidentalis* L.
Virginia pine	*Pinus virginiana* Mill.
White ash	*Fraxinus americana* L.
White oak	*Quercus alba* L.
White walnut	see Butternut
White spruce	*Picea glauca* (Moench) Voss
Willow	*Salix spp.*L.
Yellow birch	*Betula alleghaniensis* Britton
Yellow-poplar	*Liriodendron tulipifera* L.

OTHER VEGETATION	SCIENTIFIC NAME
Blackberry	*Rubus allegheniensis* Porter
Currant	*Ribes* spp. L.
Japanese honeysuckle	*Lonicera japonica* Thunb.
Kudzu	*Pueraria lobata* (Willd.) Ohwi.
Leafy spurge	*Euphorbia esula* L.
Mile-a-minute	*Polygonum perfoliatum* L.
Milkweed	*Asclepias* spp. L.
Purple loosestrife	*Lythrum salicaria* L.

INSECT SPECIES	SCIENTIFIC NAME
Balsam woolly adelgid	*Adelges piceae* (Ratzeburg)
Beech scale	*Cryptococcus fagisuga* Lindinger
Birch leafminer	*Fenusa pusilla* (Lepeletier)
Eastern spruce budworm	*Choristoneura fumiferana* (Clemens)

Elm leaf beetle	*Xanthogaleruca luteola* (Muller)
Elm spanworm	*Ennomos subsignarius* (Hubner)
European pine sawfly	*Neodiprion sertifer* (Geoffroy)
European spruce bark beetle	*Ips typographus* (L.)
Forest tent caterpillar	*Malacosoma disstria* Hubner
Gypsy moth	*Lymantria dispar* (L.)
Hemlock looper (fall)	*Lambdina fiscellaria* (Guen.)
Hemlock looper (spring)	*Lambdina athasaria* (Walker)
Hemlock scale	*Abrallaspis ithacae* (Ferris)
Hemlock woolly adelgid	*Adelges tsugae* Annand
Hickory bark beetle	*Scolytus quadrispinosus* Say
Introduced basswood thrips	*Thrips calcaratus* Uzel
Introduced pine sawfly	*Diprion similis* (Hartig)
Jack pine budworm	*Choristoneura pinus pinus* Freeman
Larch casebearer	*Coleophora laricella* (Hubner)
Larch sawfly	*Pristiphora erichsonii* (Hartig)
Larger pine shoot beetle	*Tomicus piniperda* (L.)
Pear thrips	*Taeniothrips inconsequens* (Uzel)
Red pine scale	*Matsucoccus resinosae* Bean & Godwin
Smaller European elm bark beetle	*Scolytus multistriatus* (Marsham)
Southern pine beetle	*Dendroctonus frontalis* (Zimmermann)
White pine weevil	*Pissodes strobi* (Peck)

DISEASE	CAUSAL ORGANISM
Ash yellows	MLO (Mycoplasma-like organism)
Beech bark disease(complex)	*Nectria coccinea* (Pers.:Fr.) Fr. var. *faginata* Loh., Wats., & Ay. and *N. galligena* Bres.
Butternut canker	*Sirococcus clavigignenti-juglandacearum* N.B. Nair, Kostichka & Kuntz
Chestnut blight	*Cryphonectria parasitica* (Murr.) Barr
Dogwood anthracnose	*Discula destructiva* sp. nov.
Dutch elm disease	*Ophiostoma ulmi* (Buism.) Nannf.
European larch canker	*Lachnellula willkommii* (R. Hartig) Dennis
Oak wilt	*Ceratocystis fagacearum* (Bretz.) Hunt
Scleroderris canker	*Ascocalyx abietina* (Lagerberg) Schlapfer
Sycamore anthracnose	*Apiognomonia veneta* (Sacc. & Speg.) Hohn.
White pine blister rust	*Cronartium ribicola* Fisch.

Appendix II

Quality Assurance Activities for the Northern Forest Health Monitoring Plot Network

Quality assurance procedures have been an important part of Forest Health Monitoring since the beginning of the program, and were again implemented in 1993. An effective quality assurance program includes numerous activities to help control and assess data quality. Documentation of methods and crew training insures that measurement methods are standardized among all field crews. Testing, certification, and follow up visits with crews insures that methods are used as designed. Independent remeasurement of a subset of plots allows quantification of crew performance. A debriefing of crews after the field season identifies problems which need to be corrected before the next season. All of these activities are included in the Northern Forest Health Monitoring Program.

The analysis of the remeasurement data is used as the basis of comparison of crews' performance and to make statements of confidence about the data collected in the program. Remeasurement data is evaluated for agreement with the standard data collected by the state field crews. The target for agreement between the two sets of measurements for a given indicator is called a Measurement Quality Objective. The standard and remeasurement values for each tree are compared for agreement. In 1993, the Measurment Quality Objective for crown density, crown dieback, and foliage transparency stated that at least 90 percent of the measurements should agree within two measurement classes.

Two types of remeasurement were made to document the variability of the data within a crew and between crews. Within crew remeasurements are the measurements done by a crew on a plot which that crew had measured earlier in the season. Within crew remeasurements give an indication on how well a crew can repeat a measurement on a set of trees. Between crew remeasurements are taken by an independent remeasurement crew on a plot also measured by a field crew. Between crew remeasurements supply a measure with which to gauge the consistency of the data (and of the measurement systems) between crews across the region. The results of the comparisons of the standard

data with the remeasurements for crown density and dieback, and foliage transparency for live dominant and codominant trees are shown in Appendix II Table 1.

The results show that both within crew and between crew agreement for dieback and transparency tend to decline with an increase in symptoms (for example, as transparency and dieback increase). The results for density show that within crew agreement tends to be higher than between crew agreement and that agreement tends to increase or stay the same with decreasing density. This is similar to trends that have been reported for other visual crown surveys and indicates the need to increase practice and training of crews in rating atypical trees. Transparency and dieback ratings for healthy trees were more consistent than were the ratings for density, indicating that there may still be some uncertainty in training and applying the density rating methodology, especially between crews. In addition, even though the distribution of remeasurement trees into transparency, density and dieback classes closely mirrors the full plot network, there is a need to increase the sample intensity in future quality assurance efforts to include enough trees so that estimates of agreement are reported with sufficient precision.

Appendix II Table 1. *Results of the remeasurements (within crew and between crew) for foliage transparency, crown density, and crown dieback of live dominant and codominant trees in New England and the Mid-Atlantic states, 1993. Measurement Quality Agreement (MQA) is the percent of the remeasurements which were within two classes of the standard measurement.*

	NEW ENGLAND				MID-ATLANTIC			
	Within crew (13 plots)		*Between crew (12 plots)*		*Within crew (3 plots)*		*Between crew (3 plots)*	
	NUMBER OF TREES	PERCENT MQA	NUMBER OF TREES	PERCENT MQA	NUMBER OF TREES	PERCENT MQA	NUMBER OF TREES	PERCENT MQA
FOLIAGE TRANSPARENCY								
Normal	175	99	255	98	31	100	21	100
Moderate	1	0	2	50	-	-	-	-
Total	176	99	257	98	31	100	21	100
CROWN DENSITY								
Good	97	95	116	22	19	79	15	40
Average	78	94	140	77	12	100	6	100
Poor	1	100	1	100	-	-	-	-
Total	176	94	257	52	31	87	21	57
CROWN DIEBACK								
None	136	100	207	100	29	100	21	100
Light	37	92	47	92	2	100	-	-
Moderate	3	67	3	67	-	-	-	-
Severe	-	-	-	-	-	-	-	-
Total	176	98	257	98	31	100	21	100